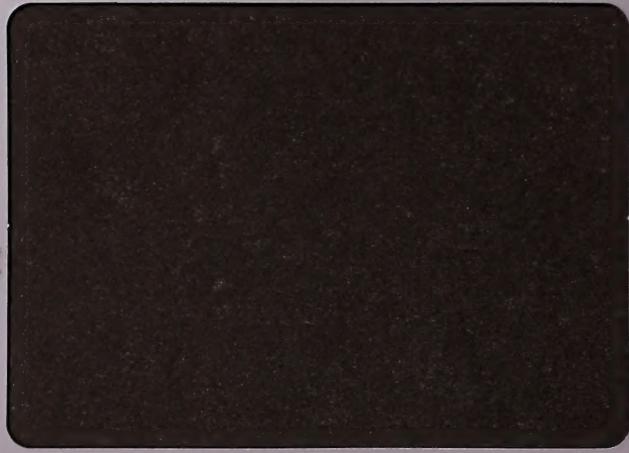


1994 Livestock Field Investigation  
of Two Ranches  
Associated with a Pipeline Break

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**1994 Livestock Field Investigations  
of Two Ranches  
Associated with a Pipeline Break**

M.S. Mostrom and C.A.J. Campbell

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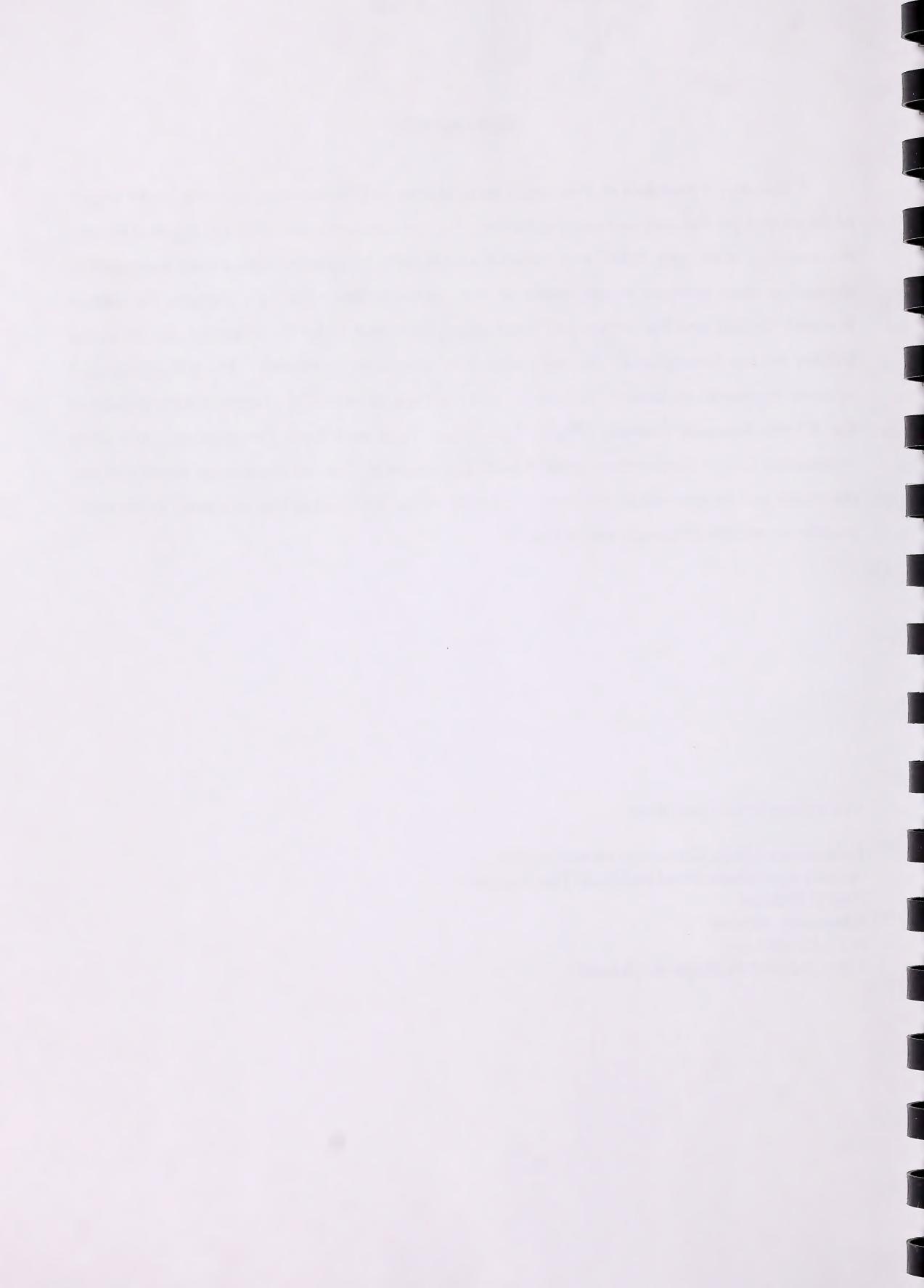


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## EXECUTIVE SUMMARY

### INTRODUCTION

The toxicology of oil- and gasfield substances in cattle is an issue in Alberta. The cattle and petroleum industries are important revenue sources. Understanding the coexistence of these industries enhances the economic prosperity of Alberta. Incidents caused by uncontrolled releases of sour petroleum do occur. Investigations of maladies in cattle following an environmental incident enhance the understanding of the toxicology of oilfield substances. However, a field investigation is not the same type of study as a controlled experiment. In a controlled experiment, exposure of cattle is precisely controlled as to substance, concentration, route and duration. Under field conditions exposure cannot be controlled as to substance(s), concentration, route and duration. When combined with experimental data, observations and data obtained from a field investigation provide insights into the toxicology of oilfield substances that result from exposure incidents.

Uncontrolled releases of petroleum do occur. In January of 1994 an uncontrolled release of sour multiphase crude petroleum occurred under the frozen Red Deer River. Odors of sour gas were important in the discovery of the leak. The company estimated the release to have started around January 6, 1994. After the leak was discovered the well was shut in and the pipeline purged of crude petroleum. Cattle on two ranches (Ranch A and Ranch B) were in the vicinity of the leak site.

The petroleum company requested an investigation into the possible toxicologic effects of the leak emissions in cattle. The Alberta Research Council has well recognized expertise in toxicology of oilfield substances in cattle.

The objectives of the investigation were to:

- Assess the health and productivity of the cattle on Ranches A and B
- Evaluate plausible etiologies for observed adverse effects in cattle
- Undertake exposure analyses.

The investigation was conducted by M. S. Mostrom, DVM, who also has a PhD in immunotoxicology and is a Diplomate of both the American Board of Veterinary Toxicology and the American Board of Toxicology, and C. A. J. Campbell, BSc, PAg.

## INVESTIGATION METHODS

Cattle on Ranches A and B were examined in detail by veterinary medical, toxicologic, and farm management procedures. The medical history captured the observations made by the ranchers and previous observations made by the field investigators. The clinical observations made by the investigating veterinarian were recorded. Cattle were evaluated by clinical observations, physical examination, and clinicopathology. The majority of animals that were moribund or died had all organ systems examined in detail by pathologic methods. Tissues were examined for antigens of infectious agents using immunohistochemical stains. Microbiological methods were used to determine the presence of infectious agents in tissues and specimens. Tissues were examined by analytical methods to determine trace nutrient and vitamin status. All laboratory determinations at the ARC were done according to established laboratory methods also known as Standard Operating Procedures (SOPs). Production and health records were also examined and compared to previous years. Meteorological data were also evaluated and applied to the morbidity and mortality observed in the herds. Exposure analyses was done on available data. Photographs and video records were used to document clinical observations.

The cattle herd owned by the Alberta Research Council was used as the control herd. This herd has a 13 year database of clinical and laboratory values, has a known status of infectious diseases, and is maintained on a ration that exceeds the NRC requirements.

## EXPOSURE ANALYSES

Exposure analyses was done using the available information. For Ranches A and B, the route of exposure to substances leaked from the pipeline was limited to the inhalation.<sup>1</sup> Sources of the volatile substances from the January 1994 pipeline leak were:

- Crude petroleum from the leak
- Products of combustion
- Volatile fractions from the remediation operations.

The leak was estimated to have started on January 6, 1994. The estimated volume of petroleum released into the environment was 40 thousand cubic meters ( $m^3$ ) of sour gas and 50  $m^3$  of sour condensate. An estimated 15  $m^3$  of condensate pooled on the ice was burned on January 8<sup>th</sup>.

---

<sup>1</sup> Cattle respire between 80 and 140 L of air per minute.

and 11<sup>th</sup>. Excavation and soil washing - sparging was done from mid-February through mid-March, 1994. Volatile substances were vented to atmosphere during the sparging operation.

The sour crude petroleum was found to be a highly complex chemical mixture. The crude petroleum was approximately 33 mole-percent hydrogen sulfide ( $H_2S$ ), 43 mole-percent hydrocarbons ( $C_2$  to  $C_{12}$ ), nine mole-percent benzene, toluene, ethylbenzene, and xylene (BTEX), six mole-percent methane ( $CH_4$ ), five mole-percent cyclopentanes, cyclohexanes, and one mole-percent trimethylbenzene, and the remainder was hydrocarbons in the  $C_{13}$  to  $C_{30}$  range. The chemistry of the products of combustion is not known. However, it can be assumed that the products of combustion were a highly complex chemical mixture and were somewhat similar to the findings of Strosner (1996). The ranchers claimed that cattle were exposed to ice smog from burning, and to substances being volatilized during the riverbed remediation operations. Because of emissions from the first ignition, Ranchers A and B were forced to evacuate their domiciles. The residents of Ranch A also evacuated their domicile because of emissions from the second ignition. After the ignition, cattle were observed to have signs of eye irritation. Clean-up operations were suspended on February 26, 1994 because of odor complaints from nearby residents.

The cattle were located in the vicinity of the pipeline leak. Cattle on Ranch A were being wintered in the river valley in a pasture that ranged from 0.5 to 2.0 km from the leak site. Immediately after the leak was discovered, cattle on Ranch A were moved to the home yard. Cattle on Ranch B were in winter quarters on the home yard when the leak occurred. Both of the ranch yards are located approximately four km from the leak site.

Other anthropogenic sources of hydrocarbons were identified before, during, and after the pipeline incident. In December 1993 sour gas was emitted from oil wells located at 9-3-34 and 7-3-34. Cattle on Ranches A and B were potentially exposed to these emissions by inhalation route of exposure. Additional pipeline failures occurred. These incidents occurred on a sour crude pipeline located west to northwest of Ranches A and B in July and in September 1994. Cattle on Ranches A and B were potentially exposed to these emissions by inhalation exposure. Another incident occurred on Ranch A in September 1994 when a blowout preventer failed (lease 9-4-34) and sour crude oil was sprayed on hay bales, trees and pasture. In this incident cattle were exposed by the inhalation route and possibly the oral route. Because of the high ambient concentrations of hydrogen sulfide, the ranch residents were requested to evacuate. Water flowing through the cattle yard at Ranch B was sampled in November 1993. The creek water was found to

contain 3.3 mg/L of extractable hydrocarbons (C<sub>43</sub> to C<sub>60</sub>) and 4 mg oil and grease/L. Because this creek flows through the cattle yard, the cattle had free access (*ad libitum*) to this water and oral exposure could have occurred. The ranchers A and B also claimed that upset conditions in other oil and gas facilities concurrent with the pipeline leak incident also decreased air quality and visibility.

In all of the potential exposures, air quality data for the ambient environment in the vicinity of the cattle was not taken or was not available for use in this investigation.

#### OBSERVATIONS IN CATTLE

Observations made in the cattle are summarized in Table 1. During the January 1994 evaluation, clinical signs of exposure to an irritating gas were observed in cattle on Ranches A and B. These signs were coincidental with exposure to the irritating gases.

Changes in maternal behavior were observed in cows in both herds. A large number of gravid cows were observed to be riding other cows (estrus-like behavior) and this number of gravid cows with estrus-like behavior was considered to be abnormal. A number of cows did not have the typical prepartum signs of enlargement of the mammary glands, and relaxation of the external genitalia. Postpartum, a large number of these cows did not have strong bonding with their calf. It is known that petroleum hydrocarbons can cause changes in the chemical communication in the brain. But, specific tests were/are not available to test cattle for these effects. The ranchers associated belligerent and aggressive behavior in their cows and some calves with the exposure incident.

There was an increase in illness and death loss in both herds. A large number of specimens from 23 different animals were tested for infectious agents (Table 2). Immunological evidence of bovine virus diarrhea (BVD) was not found in both herds (Table 1). In one animal intranuclear inclusions that could have been infectious bovine rhinotracheitis virus were identified. In all of the animals tested, IBR virus was not isolated and the IBR antigen was not identified in tissues. IBR virus was not considered to be the cause of the respiratory malady. Neonatal diarrhea was not the cause of the malady observed in calves.

Calves had a failure to thrive syndrome. After birth calves did not have a strong nursing instinct. The calves were susceptible to hypothermia. Some calves had lesions similar to those caused by *Salmonella* sp, but the infectious agent was not identified by microbiological and

immunohistochemical procedures. Calves were found to have lymphoid hypoplasia, an indicator that immune dysfunction was occurring. Calves were also found to have low transfer of  $\delta$ -globulins from ingested colostrum to their blood. It was not determined if the low transfer of  $\delta$ -globulins was due to low  $\delta$ -globulins in the cows or failure of the calves to absorb ingested  $\delta$ -globulins. Low serum levels of  $\delta$ -globulins would result in the calves having less than optimal immune protection. Some cattle have less than optimum Se status. It is not known if this contributed to immune dysfunction. Isolation of opportunistic organisms (*Enterococcus faecalis* and *Corynebacterium xerosis*) was considered to be a sequela to immune dysfunction. Immune dysfunction has been associated with exposure to petroleum hydrocarbons, and the field investigator and pathologists associated immunosuppression with exposure to the emissions from the pipeline leak and clean-up.

Histopathologic changes were observed in the upper respiratory tract of calves. Changes in the trachea were hyperplasia of the submucosal glands, discharge of the goblet cells and squamous metaplasia. This lesion was considered to have been caused by exposure to an irritating substance. Although other causes of tracheal irritation exist, irritating gas as a cause of this lesion could not be ruled out. The field investigator and veterinary pathologists considered probable links to the irritating gases as the cause of this lesion.

Some cattle had difficulty in the placement of their limbs (proprioceptive). These signs were observed in February and March. Lesions in nervous tissue were observed. Two animals may have had neurologic dysfunction caused by infectious agents. Petroleum hydrocarbons are known to cause neurologic lesions, and these lesions may be species specific. Studies on this profile of petroleum hydrocarbons have not been done in cattle. The authors have concerns that links could exist between substances emitted from the pipeline leak or the clean-up procedure and neurological dysfunction observed in the cattle.

The cold weather temperatures in February 1994 are another factor that could interact with environmental pollutants, further stressing the animals. The winter of 1988 was similarly as cold as the winter of 1994, and high unexplained calf losses did not occur on the ranches suggesting that cold weather was not, by itself, responsible for the malady.

## SUMMARY

This toxicology field investigation was in response to a request to evaluate the potential impact of a multiphase pipeline leak and clean-up on cattle health. As a field investigation into a toxicological event, not all factors can be controlled as compared with a controlled experiment. Because of the lack of exposure data, a dose-response or effect-response relationship could not be established. The authors did utilize definitive veterinary medical diagnostic procedure to establish etiologic agents of disease. The cause(s) of the malady observed in the cattle were evaluated in detail. No consistent pattern of disease other than immune dysfunction could explain the high death losses observed in calves on the ranches. Various disease etiologies were determined or indicated as possible contributors in the detailed pathological examinations. BVD virus and *Salmonella* were suspected in the histopathologic evaluation in several calves, but no positive evidence of these diseases was found using specific diagnostic virology/bacteriology testing, and the typical clinical signs of the diseases were not observed in the cattle. Corona virus was suspected in several calves but was not consistently demonstrated with diagnostic immunohistochemistry. Neonatal diarrhea was an incidental problem in these calves. Clinical signs or histopathologic lesions of selenium or copper poisoning were not reported in calves with high to high-toxic concentrations of selenium or copper. Observed clinical signs and histopathologic lesions in the respiratory, nervous and lymphoid tissues can be associated with exposure to volatile hydrocarbons released at the time of the leak and during the subsequent clean-up operations.

The 1994 calf weaning weights/selling weights and the cows that conceived in 1995 were not different when compared to other years.

This investigation is exemplary in determining the underlying causes of the malady observed in cattle on these ranches during the pipeline leak and clean-up

## REFERENCES

Strosner M. *Investigation of flare gas emissions in Alberta*. Edmonton: Alberta Research Council, 1996;30pp.

Table 1      Chronology of Observations in the Cattle

Date (1994)	Observation/Diagnosis
January 18 to 21	Anorexia
	Depression
	Anorexia
	Gaunt Appearance
	Serous ocular discharge, clouded eyes, ulcerated cornea
	Nasal discharge, sanguineous nasal discharge
	Dyspnea/Pneumonia
	Diarrhea
	Incoordination
	Vaginal discharge, sanguineous vaginal discharge
	Estrus-like behavior
February 8 to 10	Failure of cows to have signs of impending parturition
	Increased susceptibility of calves to hypothermia
	Failure of calves to nurse
	Failure of cows to bond with calves
February 14	Isolation of a non-hemolytic streptococcus from dead calf, diffuse intravascular coagulation, lymphoid hypoplasia
February 15	Staggering and goose-stepping in cows
	Hypothermia and diarrhea in a calf
	Rumenoreticulitis, possible coronaviral infection histopathology (virus antigen was not identified), bronchopneumonia, and lymphoid hypoplasia
February 21	Estrus-like behavior in a number of cows, cattle off feed
	Enterocolitis (positive coronavirus & negative rotavirus) lymphoid hypoplasia, and hypoplasia of bone marrow
	Leukomalacia of brain stem, lymphoid hypoplasia
February 27	<i>Enterococci faecalis</i> isolated, lymphoid hypoplasia, and septicemic coagulopathy
March 8	Paratyphoid-like hepatitis (negative for <i>Salmonella</i> antigens).
	Septic shock syndrome and $\alpha$ -hemolytic <i>Streptococcus</i> sp isolated
March 16	Non-suppurative tracheitis, hyperplasia of tracheal glands, lymphoid atrophy, acute pulmonary capillary leakage
	Abscesses in calves
	Lymphoid hypoplasia and omphalophlebitis

Table 1      Chronology of Observations in the Cattle (Cont'd)

Date (1994)	Observation/Diagnosis
March 17	Loss of hooves, tracheitis and hyperplasia of submucosal glands, myeloid hyperplasia
	Pulmonary congestion and capillary leakage
March 28 to 30	Pulmonary congestion with capillary leakage, necrotizing tracheitis and hyperplasia of the submucosal glands
	Pulmonary congestion with capillary leakage
	Intertubular crystal formation in the renal cortex, lymphoid stimulation
	Perforation of abomasal ulcer
	Prolapse of rectum, chronic bronchopneumonia, sloughing of claws, interstitial nephritis
	Cow moved on rear legs and front knees (low serum Ca)
	Staggering cow, sore joints, crossed rear legs while walking
March 29	Yearlings with rough hair coats and not gaining weight
	Pododermatitis, lymphoid hypoplasia
April 4	Thymic lymphoid atrophy, myeloid hyperplasia
	Euthanized cow with damage to stifle joint, found adrenocortical adenoma, tracheal submucosal gland hyperplasia
	Calf with acute abdominal discomfort, bloody diarrhea, lymphoid hypoplasia, splenica follicular hypoplasia, tracheal submucosal gland hyperplasia, colitis due to coccidia
April 14 to 15	Perforated abomasal ulcer, tracheal submucosal gland hyperplasia
	Calf with diarrhea and increased respiratory sounds
	Calf with inspiratory "honk"
	Cow with mastitis
	Cow with bloody nasal discharge and swollen front leg
April 18 to 19	Cow with abnormal gait
	Dead calf - moderate parasitic enteritis, erosion of articular cartilage, meningoencephalitis, optic perineuritis
	Incoordinated calf

Table 1      Chronology of Observations in the Cattle (Cont'd)

Date (1994)	Observation/Diagnosis
	Cow with paralysis on the left side of face, loss of motor control of tongue and was walking in circles, tracheal submucosal gland hyperplasia, bone marrow atrophy, nonsuppurative meningitis and encephalitis
April 23	Lymphoid hypoplasia, catarrhal bronchitis, perforated gastric ulcer
April 26	Lymphoid hypoplasia, tracheal submucosal gland hyperplasia
	Lymph node hypoplasia, acute abscessing bronchopneumonia, necrotic septic arthritis, and lymphoreticular nodular granulomatous hepatitis
	Acute abscessing bronchopneumonia
May 5 to 5	Necrotizing enterocolitis, viral-mycotic bronchitis with intranuclear inclusions
	Hepatic coagulative necrosis and multifocal ruminal ulcers
May 16	Bull in poor condition – weight loss since mid-April, Cow with stumbling gait
May 23	Bull with injured penis
	Pulmonary dystrophic mineralization of vessels, necrotizing bronchopneumonia, necrotic ileitis, depletion of Peyer's patches
May 31	Bull thin, anemic, purulent pneumonia with thromboembolism and vegetative endocarditis
June 22	Calf with perirenal edema and hemorrhage, and splenic atrophy and lymphoid follicular hypoplasia
November 26	Cow aborting
June 3, 1995	Cow with respiratory distress, chronic proliferative pleuritis and bronchopneumonia, lymphoid hyperplasia, degenerative ganglionic neuropathy with interneuronal lymphoid infiltration, peripheral neuropathy of sciatic nerve, status spongiosa of the spinal cord

Table 2 Results of Laboratory Tests for Infectious Agents

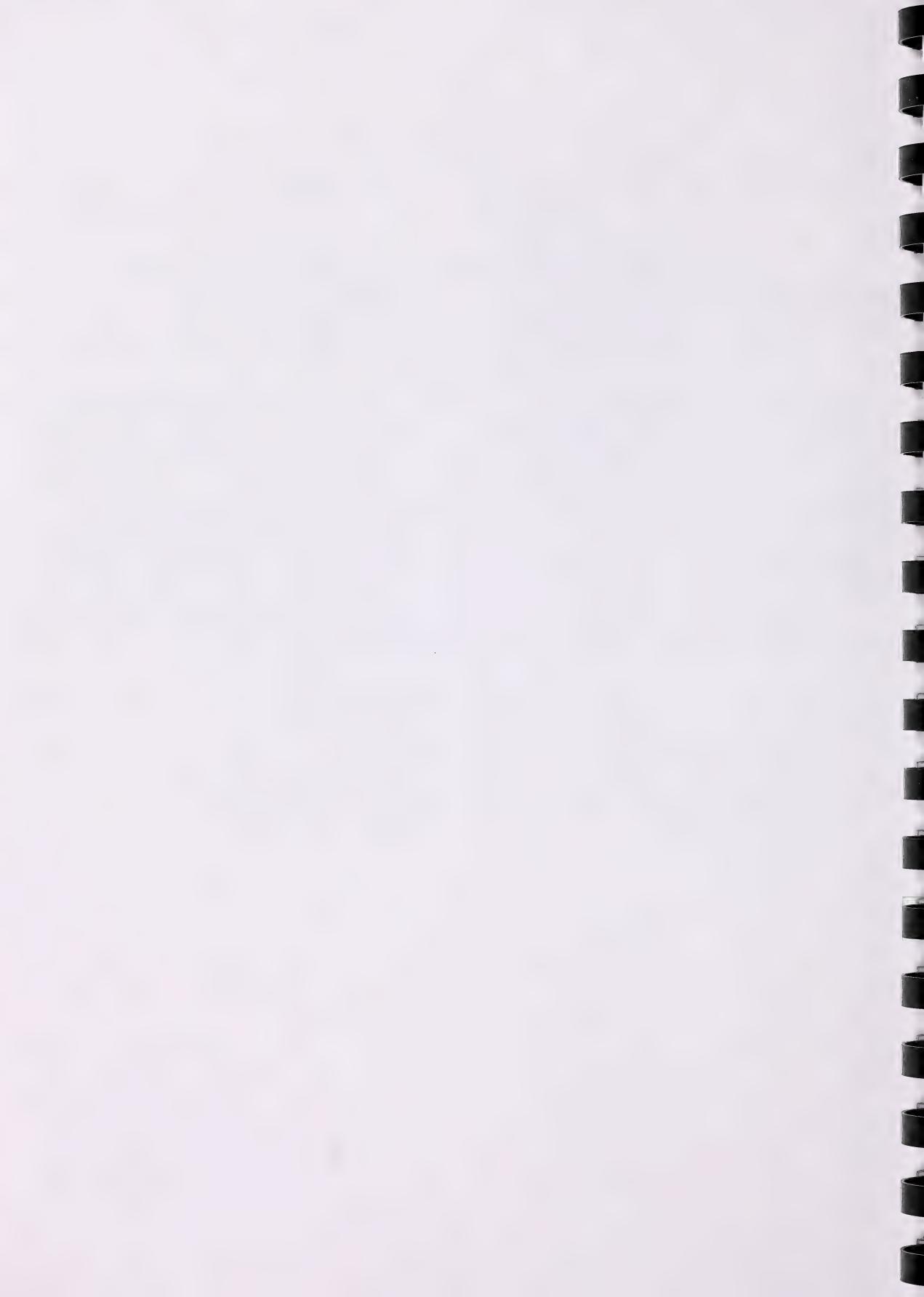
Date	Age	Test	Result
December 6 to 8	Cows	BVD	Serum titers, but virus was not isolated
		IBR	Negative
		Leptospira	5 cows out 21 were positive
January 18 to 21	Aborted fetuses	IBR, BVD, BHV-1 <sup>a</sup>	FA <sup>b</sup> and virus isolation were negative, IHC <sup>c</sup> - negative
		IBR, BVD	FA and virus isolation were negative
February 14	Calf	IBR, BVD	FA and virus isolation were negative
		Bacterial culture	Non-hemolytic <i>Streptococcus</i> sp
February 15	Calf	IBR, BVD	FA and virus isolation were negative
February 16	Calf	IBR, BVD	FA and virus isolation were negative
		Coronavirus, rotavirus	IHC - negative
February 21	Calf	IBR, BVD	FA and virus isolation were negative
		Coronavirus	IHC - positive
		Rotavirus	IHC - negative
February 27	Calf	IBR, BVD	FA and virus isolation were negative
		Coronavirus, rotavirus, BVD	IHC - negative
		Salmonella sp	IHC - negative
		Bacterial culture	<u>Enterococcus faecalis</u>
		IBR, BVD	FA and virus isolation were negative
		Bacterial culture	<u>Enterococcus faecalis</u>
	Calf	IBR, BVD	FA and virus isolation were negative

<sup>a</sup> Bovine herpesvirus type 1<sup>b</sup> Fluorescent antibody<sup>c</sup> Immunohistochemistry test

Table 2 Results of Laboratory Tests for Infectious Agents

Date	Age	Test	Result
March 8	Calf	<i>Salmonella</i> sp	IHC - negative
		Bacterial culture	Growth of coliforms (considered to be post mortem)
	Calf	Bacterial culture	Non-hemolytic <i>Streptococcus</i> sp
March 28 to 30	Calf	BVD, BHV-1	IHC - negative
April 18 to 19	Calf	<i>Leptospira</i> sp	IHC - negative
		BVD, BHV-1	IHC - negative
		<u>L. monocytogenes</u>	IHC – slight positive
April 26	Calf	Bacterial culture	Non-hemolytic <i>A. pyogenes</i>
	Calf	<i>Salmonella</i> sp	IHC - negative
		Bacterial culture	Non-hemolytic <i>A. pyogenes</i>
	Calf	<u>Hemophilus somnus</u>	IHC –positive
May 31	Bull	Bacterial culture	<i>A. pyogenes</i> , <i>S. Aureus</i> , <i>Hemophilus somnus</i>
June 3, 1995	Cow	Bacterial culture	<u>C. xerosis</u>

<sup>a</sup> Bovine herpesvirus type 1<sup>b</sup> Fluorescent antibody<sup>c</sup> Immunohistochemistry test



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## ABSTRACT

The Rocky Mountain foothill region of Alberta has intensive beef cattle and petroleum industries. Because of the biomedical knowledge known for the species, cattle are ideal biomonitorers of environmental quality. In January 1994, a pipeline leaked sour gas and condensate (including volatile hydrocarbons) into an ice-covered river. Mitigation of the spill involved ignitions of the condensate, warm water washing of river sediment, and aerosolization of river and wash water. Multiple exposures to complex mixtures occurred over time. The primary pathway of exposure was by inhalation.

Cattle adjacent to the pipeline leak were evaluated for health and productivity. The investigation of the two cow-calf herds, Ranch A and Ranch B, involved: 1) clinical observations, 2) physical examinations, 3) clinical pathology data, 4) trace nutrient analyses, 5) complete post-mortem examinations, and 6) evaluation of herd production data. Coincident with exposure to the pipeline leak and remediation, cattle displayed evidence of exposure to petroleum chemicals with irritation of the mucous membranes of the respiratory and ocular systems. Some of the cattle were pastured within one-quarter mile of the pipeline leak and clean-up operations. Thereafter, behavioral effects included unwarranted aggression and estrous like behavior in pregnant cows, poor mothering in post partum cows, and failure to thrive in the calves. Several months post-spill, cows showed proprioceptive locomotor deficits. The tissue irritancy and nervous system effects are compatible with exposure to assorted hydrocarbons in other species.

The ranches experienced an unexpected high death loss of cattle. The histopathological lesions were marked in trachea and lungs, lymphoid tissue, and nervous system. These lesions reflect damage to the route of exposure (airway) and possible lipid target of highly volatile hydrocarbons. The lymphoid tissue hypoplasia was evident in both herds, and in several calves was associated with severe disseminated intravascular coagulopathy (DIC) with isolation of opportunistic bacteria, *Enterococcus faecalis*, an organism generally isolated from human patients with compromised immune systems. Another opportunistic organism cultured in human patients, *Corynebacterium xerosis*, was grown from lung tissue of an affected cow. The calf weaning/selling weights and cow reproductive parameter - pregnant with a 1995 calf - were essentially unchanged compared with prior years.

## 1. INTRODUCTION

The Rocky Mountain foothill region of Alberta contains deciduous boreal and coniferous forests and riparian vegetation, creating important winter habitats for wintering ungulates. This Lower Boreal-Cordilleran ecoregion occupies an undulating and rolling topography (Strong and Leggat, 1992). The eastern aspect of the region is well suited for forage production, which results in a high-density cattle population. This area has extensive petroleum sour gas and oil reserves, and also has intensive development of the oil and gas industry. Zoning regulations, proximity to the oil and gas wells, and politics result in the location of petroleum industrial facilities in rural settings. Environmental interactions between the petroleum and agricultural industries have occurred over the last 50 years. Crude petroleum, sour gas, condensate, and oil field chemicals/additives are highly complex chemical mixtures. The complex chemistry underlying the toxicology of oil field compounds is not fully understood (Coppock *et al.*, 1995).

In January 1994, a multiphase pipeline carrying sour gas and condensate leaked into an ice-covered river. Mitigation of the released petroleum products included vacuuming up product on the ice surface, constructing containment berms around the spill area, two ignitions of the pooled condensate, and excavation of the river soil sediment with treatment *ex situ* (SCLCC, 1994). Cattle were considered important environmental receptors of potential adverse health effects following the incident. Two cattle ranches involved in this field investigation, Ranch A and Ranch B, are located approximately four kilometers southwest of the pipeline leak and have cattle grazing pasture adjacent to the leak. When the pipeline leak occurred, cattle from Ranch A were located on nearby pasture within one-half kilometer of the spill. Because of knowledge of these two herds from previous toxicological field studies, the Environmental Toxicology Program at the Alberta Environmental Centre (AEC)<sup>1</sup> was contacted by the petroleum company responsible for the pipeline and requested to continue toxicological field investigations of the two herds in 1994 (McQuitty, 1994).

Typical of field situations, data gaps exist in the chemical characterization of released mixtures and concentrations of chemicals reaching target sites, important data in exposure analysis. The investigation detailed the health status of two cattle herds, evaluated available exposure analytical data, and examined plausible etiologies and biological explanations of adverse effects based on existing information.

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<sup>1</sup> Now known as the Alberta Research Council (ARC)

## 2. SITE OVERVIEW

The gas processing plant is a recently developed facility located northwest of Calgary, Alberta (Figure 1). The field produces sour gas and sour condensate that is transported in multiphase pipelines to compressor stations for separation, and then processed at a central plant. In early January 1994, a leak occurred in a sour multiphase pipeline in an iced over navigable river.

The Red Deer River is a major waterway, important fish habitat, and supplies domestic water to downstream users. The area surrounding the leak and clean-up operations is agricultural, primarily used for cattle production. The site is located in a highly developed petroleum field containing oil and sour gas wells, compressor stations, and batteries which flare disposal gaseous waste streams or products during upset conditions (Figure 2). A description of the lease sites surrounding Ranch A and B are provided in Table 1. The petroleum products are transported by buried pipelines, which criss-cross the landscape.

The two cattle ranches in our investigation, Ranch A and Ranch B, are located within four kilometres southwest of the pipeline leak (Figure 2). These cattle were included in our investigation because of proximity to the leak and prior knowledge of the herd health status. Four sour gas plants (west, northwest and northeast) are located within 20 kilometres of these ranches. The ranches are cow-calf operations with approximately 300 pregnant cows at Ranch A and 160 pregnant cows at Ranch B which calved in 1994. At the time of the pipeline leak, a majority of Ranch A cows were pastured within two kilometres of the leak. Subsequently, cows at both ranches were brought into more confined areas for clinical observations. Calving started in mid-January at both ranches.

## 3. INCIDENT

Three days prior to the discovery of the pipeline leak, local residents reported smelling noxious odors. Upon discovery of the leak, the flowing well was shut in and the line depressurized. The company estimates approximately  $40 \times 10^3 \text{ m}^3$  of sour gas and  $50 \text{ m}^3$  of sour condensate escaped into the river (SCLCC, 1994). Tables 2 and 3 detail the sour gas and condensate analyses, respectively, of the 5-32 well, which is located approximately two kilometres from the flowing well (8-1 well)<sup>1</sup>. The chemical characterization of the flowing well was not

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<sup>1</sup> The wells are from the same production zone (Harry Lillo, AEUB, personal communication)

Figure 1

Map of Alberta Illustrating the Location of the Leak (Arrow) in a Pipeline Gathering System for the Sour Gas Plant

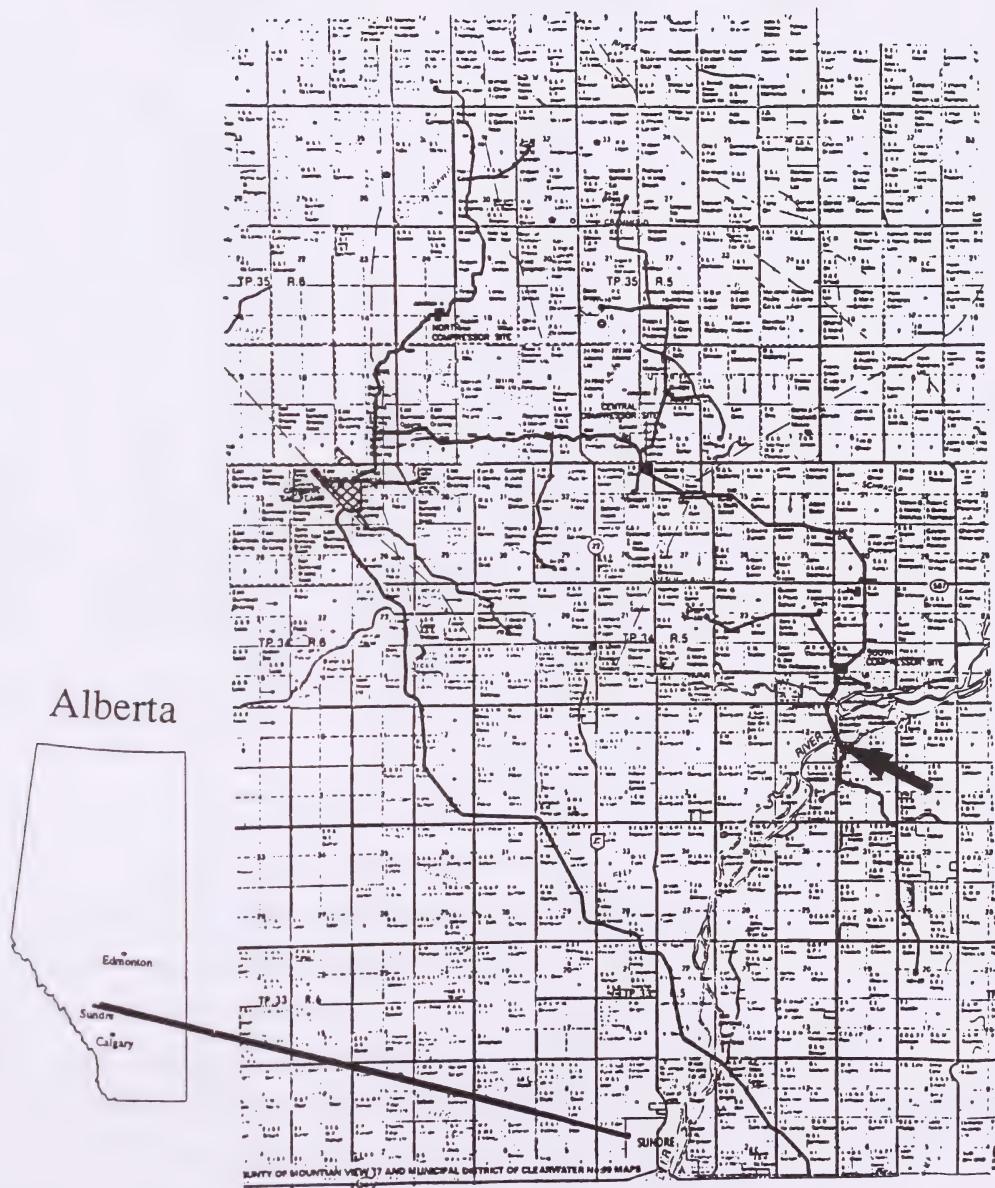
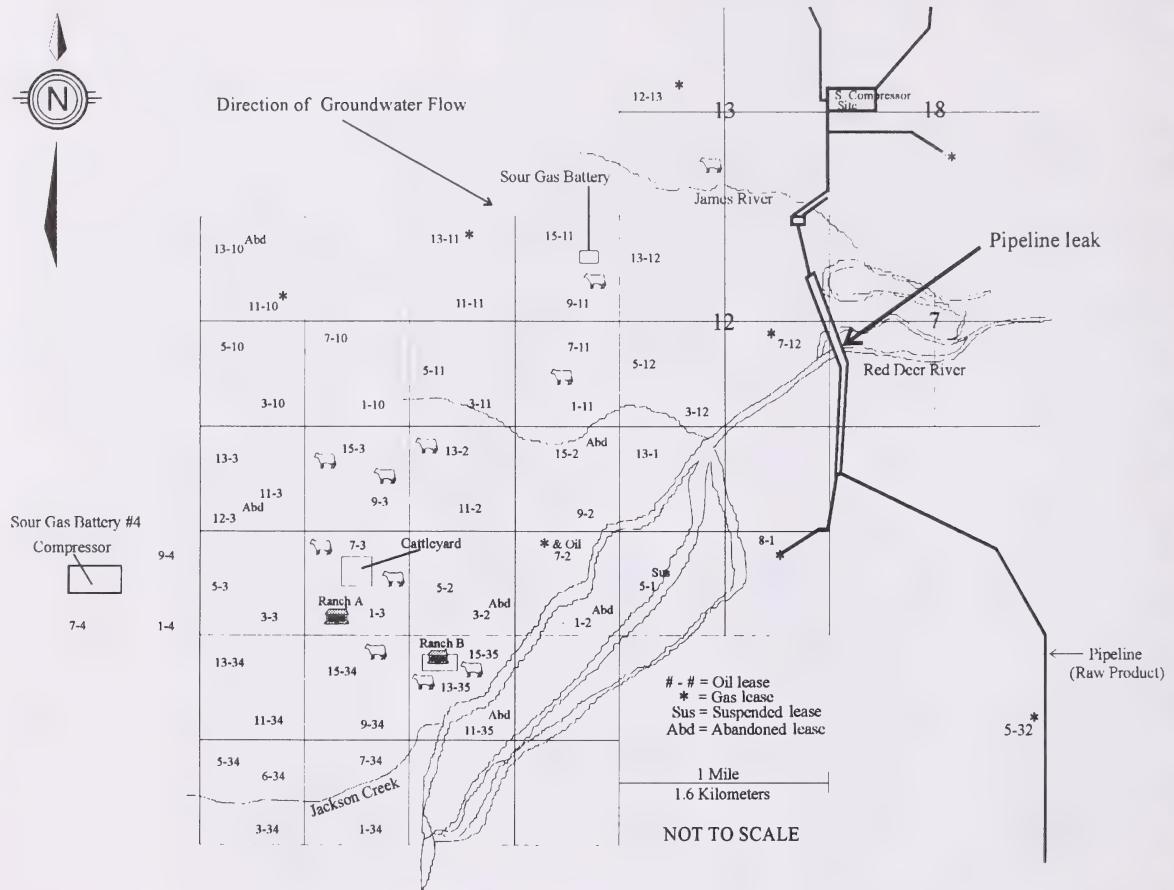


Figure 2

Drawing of Oilfield Installations and Ranch Locations (Large Arrow Depicts Location of Leak)



available. The escaped mixtures contained over 30% hydrogen sulfide. The condensate was predominately lower chain hydrocarbons, C<sub>1</sub> to C<sub>9</sub>, aliphatics and monoaromatics (Table 3).

Most of the sour gas escaped into the atmosphere. A portion of the volatile hydrocarbons dissolved in the water, and condensate was entrained in the river sediment. Sulfur products and the free-phase condensate pooled on the ice covered river surface. Vacuum trucks removed an estimated 20 m<sup>3</sup> of free-phase condensate pooled on the ice surface (SCLCC, 1994). An estimated 15 m<sup>3</sup> of condensate was burned within five days of the spill in two ignitions, January 8 and January 11 (SCLCC, 1994). Dams and containment berms were constructed to stop further

Table 1 Description of Lease Sites Surrounding Ranches A and B Alberta Energy and Utilities Board (AEUB)<sup>1</sup> 1995

Description	Status	Drilling Date
00/01-35-33/0	Crude Oil Pump	16 Dec 1970
00/05-35-33/0	ABD <sup>a</sup>	25 Aug 1957
00/06-35-33/2	Crude Oil Pump	08 Sep 1993
00/09-35-33/0	Crude Oil SUSP <sup>b</sup>	04 Apr 1959
00/11-35-33/0	Crude Oil ABDWHP <sup>c</sup>	02 Aug 1959
00/13-35-33/0	Crude Oil Pump	28 Jun 1957
00/15-35-33/0	Crude Oil Pump	16 Jun 1958
02/15-35-33/0	Gas Flow	18 Jul 1988
02/15-35-33/2	Crude Oil Flow	18 Jul 1988
00/05-01-34/0	Crude Oil SUSP	25 Nov 1959
00/08-01-34/0	ABZONE <sup>d</sup>	05 Jun 1985
00/08-01-34/2	Gas Flow	05 Jun 1985
02/08-01-34/0	Gas Flow	10 Sep 1988
00/01-02-34/0	Water ABD Injection	09 May 1959
F1/02-02-34/0	Water	06 Aug 1965
F2/02-02-34/0	Water	01 Oct 1965
F3/02-02-34/0	Water Potential	31 Aug 1965
00/03-02-34/0	Water Injection	13 Apr 1958
S0/03-02-34/0	ABD	17 Sep 1953
00/05-02-34/0	Water Injection	04 Mar 1958
00/07-02-34/0	Crude Oil Pump	28 Feb 1959
02/07-02-34/0	Gas Flow	29 Oct 1988
02/07-02-34/2	COMMING <sup>e</sup>	29 Oct 1988
00/09-02-34/0	Crude Oil SUSP	11 Jul 1959
F1/09-02-34/0	Water ABD	18 Nov 1963
F2/09-02-34/0	Water ABD	27 Jun 1964
00/11-02-34/0	Crude Oil Pump	20 Jun 1958
00/13-02-34/0	Crude Oil Pump	05 Mar 1988
00/15-02-34/0	ABD	18 Sep 1959
00/01-03-34/0	Crude Oil Pump	10 Apr 1957
00/03-03-34/0	Crude Oil Pump	21 Apr 1955
00/05-03-34/0	Crude Oil Pump	28 Nov 1955
00/07-03-34/0	Crude Oil GASLFT <sup>f</sup>	27 Feb 1957
00/09-03-34/0	Crude Oil GASLFT	17 Oct 1957

<sup>1</sup> Formerly known as the Energy Resources Conservation Board (ERCB)

<sup>a</sup> Abandoned

<sup>b</sup> Suspended

<sup>c</sup> Abandoned – possible waiting to abandon whipstock or directional well

<sup>d</sup> Abandoned zone

<sup>e</sup> Commingled - meaning it is producing from two zones that are separate formations, but close in bottom hole pressure

<sup>f</sup> Plunger in string. No pump jack, gas pressure pushes plunger up when the pressure builds up then drops back to bottom

Table 1 Description of Lease Sites Surrounding Ranches A and B (AEUB, 1995) (Cont'd)

Description	Status	Drilling Date
00/11-03-34/0	Crude Oil Pump	08 Nov 1956
00/12-03-34/0	ABD	12 Mar 1974
00/13-03-34/0	Water Injection	12 Sep 1956
00/15-03-34/0	Crude Oil GASLFT	04 Jul 1957
00/01-04-34/0	Crude Oil Pump	10 Jan 1955
00/06-04-34/0	Gas Flow	11 Jan 1986
00/06-04-34/2	Gas SUSP	11 Jan 1986
00/07-04-34/0	Water Injection	09 May 1956
00/09-04-34/0	Crude Oil Pump	30 Sep 1955
00/11-04-34/0	Water Injection	26 Jul 1955
00/13-04-34/0	ABD	17 Sep 1953
00/15-04-34/0	Crude Oil SUSP	04 Jun 1955
00/01-10-34/0	Crude Oil Flow	24 Jul 1989
00/03-10-34/0	Crude Oil Flow	14 Apr 1957
00/05-10-34/0	Crude Oil Pump	21 Feb 1957
00/07-10-34/0	Crude Oil Flow	24 Jan 1990
00/11-10-34/0	Gas Flow	18 Oct 1957
00/13-10-34/0	ABD	03 Aug 1990
00/01-11-34/0	Crude Oil Flow	17 Nov 1989
00/03-11-34/0	Crude Oil Flow	10 Nov 1989
00/05-11-34/0	Crude Oil Pump	21 Nov 1988
00/07-11-34/0	Crude Oil Flow	15 Nov 1987
00/09-11-34/0	Crude Oil Flow	15 Jul 1962
00/11-11-34/0	ABD	25 Sep 1989
00/11-11-34/0	Crude Oil Flow	19 Mar 1991
00/13-11-34/0	Crude Oil ABZONE	31 Mar 1963
00/13-11-34/2	Gas Flow	31 Mar 1963
00/15-11-34/0	Crude Oil Flow	27 Mar 1962
00/03-12-34/0	Crude Oil Flow	25 Nov 1990
00/05-12-34/0	Crude Oil Flow	25 Feb 1963
00/07-12-34/0	Crude Oil ABZONE	28 Oct 1985
00/07-12-34/2	Gas Flow	28 Oct 1985
00/13-12-34/0	Water Injection	16 Feb 1962

<sup>a</sup> Abandoned

<sup>b</sup> Suspended

<sup>c</sup> Abandoned – possible waiting to abandon whipstock or directional well

<sup>d</sup> Abandoned zone

<sup>e</sup> Comingled - meaning it is producing from two zones that are separate formations, but close in bottom hole pressure

<sup>f</sup> Plunger in string. No pump jack, gas pressure pushes plunger up when the pressure builds up then drops back to bottom

Table 2 Sour Gas Analysis (Sample Date 1993/11/09) of the Nearby 5-32 Well, (SCLCC, 1994)

Component	Content	Units
N2	1.69	Mole%
CO2	7.09	Mole%
H2S	33.90	Mole%
C1	41.95	Mole%
C2	8.68	Mole%
C3	3.28	Mole%
iC4	0.79	Mole%
nC4	1.43	Mole%
iC5	0.34	Mole%
nC5	0.44	Mole%
C6+	0.42	Mole%

condensate migration downstream and to divert the Red Deer River flow away from the spill area. A majority of the clean-up operations were located adjacent to the leak, on the south river bank.

The clean-up operations have been described (SCLCC, 1994). Briefly, remediation involved extraction of contaminated river sediment, draining the sediment on a liner for liquid collection, and using a warm water pressure wash of the soil to remove hydrocarbons physically and through volatilization (SCLCC, 1994). Aeration towers and air blowers were used to remove pollutants from the soil wash water and from the melted ice contaminated with condensate. Air spargers were utilized in the excavation area and downstream control pond for reducing dissolved hydrocarbon concentrations in the water. Excavation and the soil washing program were operational from mid-February through mid-March. Guidelines used for the clean-up were the Alberta Environment Tier I criteria for sediment and Canadian Drinking Water Quality and the Canadian Council of Ministers of the Environment (CCME) Freshwater Aquatic Toxicity values for water. The company estimated 6 to 12 m<sup>3</sup> of condensate was removed from the sediment with over 50% volatilized into the atmosphere (SCLCC, 1994). Following the pipeline repair in mid-March, the river channels were reconstructed and the area returned to near natural conditions before the spring thaw.

Table 3 Condensate Analysis (Sample Date 1993/11/09) of the Nearby 5-32 Well  
(SCLCC, 1994)

Component	Content	Units
N <sub>2</sub>	0.08	Mole%
CO <sub>2</sub>	2.29	Mole%
H <sub>2</sub> S	32.67	Mole%
C <sub>1</sub>	6.06	Mole%
C <sub>2</sub>	5.35	Mole%
C <sub>3</sub>	5.28	Mole%
iC <sub>4</sub>	2.56	Mole%
nC <sub>4</sub>	6.24	Mole%
iC <sub>5</sub>	2.94	Mole%
nC <sub>5</sub>	4.60	Mole%
C <sub>6</sub>	6.29	Mole%
C <sub>7</sub>	4.08	Mole%
C <sub>8</sub>	2.22	Mole%
C <sub>9</sub>	1.19	Mole%
C <sub>10</sub>	1.76	Mole%
C <sub>11</sub>	0.65	Mole%
C <sub>12</sub>	0.28	Mole%
C <sub>13</sub>	0.14	Mole%
C <sub>14</sub>	0.07	Mole%
C <sub>15</sub>	0.05	Mole%
C <sub>16</sub>	0.05	Mole%
C <sub>17</sub>	0.06	Mole%
C <sub>18</sub>	0.09	Mole%
C <sub>19</sub>	0.14	Mole%
C <sub>20</sub>	0.06	Mole%
C <sub>21</sub>	0.03	Mole%
C <sub>22</sub>	0.01	Mole%
C <sub>23</sub>	0.01	Mole%
C <sub>24</sub>	0.00	Mole%
C <sub>25</sub>	0.00	Mole%
C <sub>26</sub>	0.01	Mole%
C <sub>27</sub>	0.00	Mole%
C <sub>28</sub>	0.00	Mole%
C <sub>29</sub>	0.00	Mole%
C <sub>30</sub>	0.00	Mole%
BENZENE	0.50	Mole%
TOLUENE	3.23	Mole%
ETHYLBENZENE	0.35	Mole%
P,M - XYLENE	3.55	Mole%
O - XYLENE	1.14	Mole%
1,2,4 TRIMETHYLETHYLBENZENE	0.99	Mole%
CYCLOPENTANE	0.59	Mole%
METHYLCYCLOPENTANE	1.48	Mole%
CYCLOHEXANE	1.04	Mole%
METHYLCYCLOHEXANE	1.87	Mole%

#### 4. APPROACH TO THE INVESTIGATION

The petroleum company and local residents were concerned with the potential impact of emissions from the leak affecting the environment and health. One of the monitoring programs was the investigation into cattle health and productivity; Environmental Toxicology (AEC) evaluated cattle health and productivity at two ranches, Ranch A and Ranch B.

Cattle are an economically important industry in the area and were considered a target species. Cattle are continuous air monitors, a cow breathes every 2 to 3 seconds with a minute volume of approximately 80 L (liter) min<sup>-1</sup> (Lumb and Jones, 1984). Adult cows can drink 40 to 60 L daily and eat 2.4% to 2.7% of their bodyweight in food daily. Under grazing conditions, soil can account for almost 10% of the dry matter intake (Healy, 1968). Ruminants, including cattle, are sensitive to petroleum hydrocarbon (Coppock *et al.*, 1996; Coppock *et al.*, 1995; Mostrom *et al.*, 1993; Adler *et al.*, 1992; Edwards *et al.* 1979; Stober, 1962) and sour gas exposures (Edwards, 1992; Coppock *et al.*, 1986).

#### 5. OBJECTIVES

- (1) Assess the health and productivity of two cow-calf herds using basic veterinary diagnostic techniques following a sour gas and condensate leak and clean-up.
- (2) Evaluate plausible etiologies for observed adverse effects in the cattle herds.
- (3) Using available exposure data, assess the exposure - response relationship in cattle.

#### 6. METHODS TO ASSESS IMPACT ON CATTLE HEALTH AND PRODUCTIVITY

- (1) Clinical examinations of cattle were conducted by a veterinarian, except where noted as owner observations.
- (2) Blood samples were collected in vacuum tubes with no additive (Vacutainer, Becton Dickinson and Company, Franklin Lakes, New Jersey). The blood was allowed to clot well and centrifuged at 2500 rpm for 15 minutes. If the serum contained a large amount of fibrin, the sample was re-spun at 2500 rpm for 10 minutes, then the serum was decanted into another tube for analyses or storage. Blood serum chemistries included a routine bovine screen and were analyzed on a Hitachi 704 Biochemistry Analyzer (Hitachi, Tokyo, Japan) using chemistry kits from Boehringer Mannheim (Montreal, PQ, Canada). Appropriate controls were

- conducted (Appendix A, revised SOP 2600-M1\*AJ4[MEQP/HITA/1/97]. Plasma fibrinogen concentrations were determined using a microhematocrit heat precipitation method (Appendix A, revised SOP 2600-M1\*AJ4[ANL/HEM/2/96).
- (3) Whole blood samples were collected in EDTA (ethylenediaminetetraacetic acid) vacuum tubes (Vacutainer, Becton Dickinson and Company, Franklin Lakes, NJ), and hematology was evaluated with a Coulter S-plus IV hematology analyzer (Coulter Electronics Inc., Hialeah, FL)(Appendix A, revised SOP 2600-M1\*AJ4[MEQP/CLTR/3/97). Blood films were prepared for manual determination of the white blood cell differential count and morphology assessment (Wright-Giemsa stain, Appendix A, revised SOP 2600-M1\*AJ4[ANL/HEM/9/96) (Appendix A, revised SOP's 2600-M1\*AJ4[ANL/HEM/10/96 and 2600-M1\*AJ4[ANL/HEM/1/96).
- (4) Determination of serum immunoglobulins was by protein electrophoresis (Appendix A, revised SOP 2600-M1\*AJ4[ANL/CCH/9/97).
- (5) Post-mortem examinations by a veterinarian followed a routine procedure (Appendix A, revised SOP 2600-M1\*AJ4[PR/NEC/7/95) where possible in field necropsies.
- (6) Samples of selected tissues were collected in 10% neutral buffered formalin or Bouin's fixative (Appendix A, revised SOP 2600-M1\*AJ4[ANL/HST/1/95). Subsequently, tissues were grossly trimmed for light microscopic evaluation (Appendix A, revised SOP 2600-M1\*AJ4[ANL/HST/28/96) and processed routinely for hematoxylin and eosin staining for general histopathological assessment. The tissues were then processed and embedded in wax (Appendix A, revised SOP's 2600-M1\*AJ4[EQP/HST/9/96 and 2600-M1\*AJ4[ANL/HST/6/95). The tissues were stained with hematoxylin and eosin (Appendix A, revised SOP 2600-M1\*AJ4[ANL/STN/2/96), periodic acid Schiff stain (Appendix A, revised SOP 2600-M1\*AJ4[ANL/STN/4/96), Giemsa's stain (Appendix A, SOP 2600-M1\*AJ4[ANL/STN/21), Warthin-Starry stain for spirochetes (Appendix A, revised SOP 2600-M1\*AN4[ANL/STN/11), Gram stain (Appendix A, revised SOP 2600-M1\*AJ4[ANL/STN/27/96), Oil Red O (Appendix A, revised SOP 2600-M1\*AJ4[ANL/STN/23/96), or special stains (Appendix A, see list of references of

special stains). Following tissue staining, the glass slides were coverslipped (Appendix A, revised SOP 2600-M1\*AJ4[ANL/HST/7/95] and assessed (Appendix A, revised SOP 2600-M1\*AJ4[ANL/HST/8/95]).

- (7) The histopathologic examination of the tissues for each necropsied animal was performed by Diplomates of the American College of Veterinary Pathologists (Stair and Kosanke, 1997). The morphological diagnosis, severity of the lesion, and amount of post-mortem autolytic changes were determined for the tissues, and the histopathological findings were generated in conjunction with data acquired from the field investigations.
- (8) Blood samples for trace mineral analyses were taken in Royal Blue vacuum tubes (Vacutainer, Becton Dickinson and Company, Franklin Lakes, NJ) with no additive or with sodium heparin. Analyses were performed for whole blood selenium and plasma selenium, plasma copper, and plasma zinc. Tissue (liver and kidney) samples were collected in polyethylene bags (Whirl-Pak, Nasco, Fort Atkinson, WI) and frozen at -20°C for trace mineral determinations. See Appendix A for the Standard Operating Procedures for selenium (2600-M1\*AJ4[ANL/TOX/16/91] contains the method for tissue digestion and 2600-M1\*AJ4[ANL/TOX/14 contains the procedure for operation of the Varian atomic absorption spectrophotometer), copper (2600-M1\*AJ4[ANL/TOX/12]), and zinc (2600-M1\*AJ4[ANL/TOX/15/91]). Tissue trace mineral results were reported on a dry weight basis (ng/g or µg/g).
- (9) Blood was taken in vacuum tubes (Vacutainer, Becton Dickinson and Company, Franklin Lakes, NJ) with no additive or with sodium heparin for serum or plasma samples, respectively. The serum or plasma samples were stored at -20°C. Serum or plasma analysis for vitamin E was determined by high pressure liquid chromatography with spectrofluorometric detection (Appendix A, SOP 2600-M1\*AJ4[ANL/TOX/17/95]).
- (10) Selected tissues were collected in sterile containers and submitted to a laboratory (Palliser Animal Health Laboratories Ltd., Lethbridge, AB) for microbial culture and identification. Blood or serum samples for serology (Bovine Virus Diarrhea Virus [BVD], Infectious Bovine Rhinotracheitis virus [IBR] and leptospirosis) were submitted to Palliser Animal Health Laboratories Ltd. Selected tissues and paraffin

tissue samples were submitted to the Western College of Veterinary Medicine (Saskatoon, SK) for virus isolation and fluorescent antibody tests and diagnostic immunohistochemistry.

- (11) The Alberta Environmental Centre cow-calf herd was used to establish several normal range values in clinical pathology for comparison with the ranch cattle. The AEC cattle are routinely immunized against common bovine diseases, treated with antiparasitics, and maintained on a diet which meets or exceeds the National Research Council's beef cattle recommendations (NRC, 1996). The surrounding area petroleum development is sweet gas. Flaring of waste gases by the petroleum industry is an uncommon practice in this area.

#### 6.1 Time Frame for the Investigation

The 1994 cattle investigation was initiated in January following the pipeline leak. The primary concerns were possible affects on calf viability, on calf growth (measured as weaning or sales weights), and on reproductive efficiency or the ability of the cow to produce a live calf in 1995.

#### 6.2 Parameters Used for the Investigation

Cattle health was evaluated by observation for clinical signs, physical examinations, serum chemistries and hematology, and serology for infectious diseases. The data was documented in a logbook, and where appropriate, pictures and videotapes. Cattle owner data on abnormal clinical signs, morbidity, treatments used and responses, feeds and nutritional supplements, and deaths or mortality were utilized. Whenever possible, dead animals were examined in necropsy procedures and tissue samples were taken for histopathology, microbiology, virology, and analytical toxicology.

Ranch owner calving record data, including date and difficulty in calving, sex, birth weight, twinning rate, and age of dam were used in assessing health and productivity. Where available, the fall calf weaning/selling weights and the female (cow or heifer) pregnancy examination data were evaluated.

### 6.3 Exposure Analysis

The sequence of multiple point source exposures will be described. The leak of sour gas and condensate, containing greater than 30% hydrogen sulfide, occurred in early January (Tables 2 and 3). The condensate contained approximately 8.8 mole% of BTEX in addition to the lower-chain hydrocarbons (Table 3). Following the spill, the free-phase condensate pooling on ice was ignited twice (January 8 and 11), releasing products of combustion, such as reduced sulfur compounds and polyaromatic hydrocarbons. Nearby residents described the plume of combustion as a black ice fog. Residents of both Ranch A<sup>1</sup> and B reported that they evacuated during the first ignition due to intense noxious odors. Ranch<sup>2</sup> A residents also evacuated during the second ignition. The owner of Ranch A reported that the odors left in household fabrics were offensive and strong, and were advised by the oil company, to have furniture and vehicles steam cleaned. The Ranch B residents reported that they disposed of some house furniture because they could not remove the offensive odors from the fabric. Both ranch owners reported that their companion pets left at the residences were depressed (dogs), vomited and ataxic (cats), and died (baby ducks). A majority of the cattle on Ranch B were confined adjacent to the residence. The cattle on Ranch A were adjacent to the leak or near the residence.

Depending on physical/chemical properties, volatile hydrocarbons were released in the initial spill and during the clean-up operations involving soil washing and water aerosolization. Clean-up operations were shut down on February 26 because of odor complaints from nearby residents; the odors were apparently associated with clean-up of a more highly contaminated sediment. The clean-up operation time frame was February through March 17, followed by reconstruction of the riverbanks.

In addition to the events surrounding the January pipeline break, on a fairly regular basis incineration products were released during the flaring of gaseous waste streams at batteries and other petroleum leases in the area. Throughout the spring and summer, owners of both ranches described plumes of gaseous materials, detected by sight or smell, moving through the area. The plumes did not consistently have the same color of sulfur or hydrocarbon odors. The ranch owners, and at times the authors, after exposure to these emissions, reported clinical signs of numbness of the lips, tingling at the back of the throat region, nausea, and headaches.

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<sup>1</sup> Told to evacuate by phone. Red Deer ERCB Phone Record

<sup>2</sup> Told to evacuate by oil company

Several additional pipeline leaks, releasing crude oil, occurred west to northwest of Ranches A and B in July and September, 1994. Also, in early September 1994, a blowout preventer apparently malfunctioned on an oil pumper located north of Ranch A (lease 9-4-34). Sour gas and crude oil were released, and the ranch residents were requested to evacuate the area. Cattle were grazing in a nearby field throughout this incident.

#### 6.4 Limitations for Exposure Analysis

The primary route of exposure to the cattle was inhalation; dermal absorption of volatilized compounds would have been minimal. The cattle on Ranches A and B had no known exposure to condensate through water consumption.

The main focus of environmental monitoring at or near the incident site was on soil and water contamination (SCLCC, 1994). The chemical analyses for the 8-1 well were not available. Air monitoring was primarily for occupation health and safety concerns on the work site. Limited air monitoring data was available and difficult to interpret. No chemical composition data was available on the plumes resulting from condensation ignitions for this report. Additionally, no air monitoring for chemicals of toxicological concern was conducted in pastures on Ranches A and B where cattle might have exposure to fugitive emissions. The topography of the area, which includes the Red Deer and James River valleys, rising elevations to the east, and the Rocky Mountain foothills terrain, would make extrapolation of air monitoring data difficult from site-to-site. Surface flow of air is highly variable due to eddies created by the topography.

### 7. RESULTS AND DISCUSSIONS

#### 7.1 Field Investigations - Recent Background of Ranches A and B

*November 25, 1993.* The owners of both Ranches A and B reported about a three-hour exposure to a black smoke cloud on their ranches, and the owner of Ranch A reported the visibility was less than 100 meters.

*November 26, 1993.* A field trip was made by M. Mostrom and S. Herbut to Ranch B for water sampling at Jackson creek and soil sampling adjacent to the creek near the 11-35-33 lease site. Cattle were pastured in this area. Water samples contained 3.3 ppm by weight (C43 to C60) of extractable hydrocarbons (sample No. 930587) and oil and grease measured at 4 mg/L (ppm)

(sample No. 930588) (Mostrom, 1994a). The field team visually examined cattle in the herd and detected no apparent involvement of upper respiratory system at this time.

A field trip to Ranch A was made for data acquisition on culled cows and herd additions, and to view the cattle. No abnormal clinical signs were observed.

## 7.2 Field Investigation of Ranch A

December 6-8, 1993. A field investigation was made by M. Mostrom and C. Campbell to Ranch A. The owner of Ranch A reported that several petroleum lease sites, 9-3-34 and 7-3-34, emitted a strong sour gas odor for several hours in early December. The ranch owner reported that the regulatory agency (AEUB) informed him that the 9-3 well had a valve malfunction, and the 7-3 well had a packing problem with reportedly a measurement of 8 ppm of H<sub>2</sub>S around the well site.

A portion of the cow herd was pastured adjacent to these wells in late November and early December. Two cows, ear tags OR2 (ID No. 930599) and Y38 (ID No. 930593), aborted calves in early December. As part of the field investigation into potential adverse effects associated with petroleum pollution, a decision was made to try to establish the cause of death in the aborted fetuses by post-mortem examination. And, since most of the herd was pastured adjacent to the wells, these cows were brought into the cattle yard for re-tagging for efficient identification of animals and to take blood samples from about 10% of the herd for serological evaluation for specific diseases. Table 4 lists the individual cows and the animals bled for serology and trace nutrient analyses for copper and selenium status. The cows were processed through a cattle chute for re-tagging. The ranch owner vaccinated the cows with CattleMaster4-L5® (SmithKline Beecham or Pfizer, West Chester, PA) and injected the cows with 6 mL of Dystosel® (rogar/STB Inc., Pointe Claire-Dorval, PQ). The owner reported that in the fall the cows were injected with Dystosel®, Vitamins A and D, and treated for lice and grubs (Neguvan®, Bayer Inc., Etobicoke, ON).

Serology results from December are listed in Table 5. The IBR titers ranges from 1:22 through 1:78. All of the cows blood tested had titers against BVD virus greater than 1:256 and no BVD virus was isolated in the samples. The leptospirosis titers were negative against *Leptospira interrogans* serovars *pomona*, *icterohaemorrhagiae*, *canicola*, *copenhagenii*, *grippotyphosa*, *bratislava*, and

Table 4 Ranch A Cattle Bled and Re-tagged on December 6-7, 1993

1993 Tag <sup>1</sup>	Old Tag <sup>2</sup>	ID No. <sup>3</sup>	Breed	Comments
	Yellow 38Y	930593 <sup>a,b</sup>	Simm X	Mouse WF
Green 1	White 8	900553 <sup>a</sup>		
Green 2	Orange 4	900568 <sup>a</sup>	Simm	
Green 3	Y 202	930594 <sup>a</sup>	Saler	Red on NW2
Black 1		930595 <sup>a</sup>		Light red blaze face
Green 4		930596 <sup>a</sup>		Hydrocarbons- had twins
Green 5		930597 <sup>a</sup>	Angus	Black - Heidi's milk cow
Green 6	Yellow 188	911084	Saler	Mate to G3 on NW2
Green 7	K 53	930598 <sup>a</sup>	Angus X	BWF, 15 years
Green 8	Orange 1	900566 <sup>a</sup>	Simm	Hydrocarbons
Green 9	White 3	900548 <sup>a</sup>		Control cow
Green 10	Orange 2	900567 <sup>a</sup>	Simm	Hydrocarbons Brisket 5
	Orange R2	930599 <sup>a,b</sup>	Angus X	Red bald face
Green 11	Orange 6	900569 <sup>a</sup>	Simm	Brisket 7G
Green 12	Blue 99	900397 <sup>a</sup>	Simm	Hydrocarbons
Green 13		930600 <sup>a</sup>	Angus	Black, old cow
Black 2		930601 <sup>a</sup>		
Green 14		930602	Angus	Red
Green 15		930603 <sup>a</sup>	Angus	Black
Green 16		903604	Simm X	Mouse WF, old
Green 17	132 X	930605 <sup>a</sup>		Old cow
Black 3		930606		
Green 18		930607 <sup>a</sup>		Red roan
Green 19		930608 <sup>a</sup>		Red

<sup>1</sup> Tag placed in ear to identify cow on the study

<sup>2</sup> Number of existing tags present when animal was retagged

<sup>3</sup> AEC specimen identification

<sup>a</sup> Blood samples obtained (red top Vacutainers, Becton-Dickinson, Franklin, NJ) for serology

<sup>b</sup> Aborted in early December, 1993

Table 4 Ranch A Cattle Bled and Re-tagged on December 6-7, 1993 (Cont'd)

1993 <sup>1</sup> Tag	Old Tag <sup>2</sup>	ID No. <sup>3</sup>	Breed	Comments
Green 20	Green 49Z	930609	Saler	
Green 21	Green 5Y	930610 <sup>a</sup>	Simm X	
Green 22			Hereford	
Green 23	Green M8		Hereford	
Green 24	White 113 <u>CA</u>		Hereford	
Green 25	Blue B25		Char	Tan
Green 26	Orange J54		Angus	Black
Green 27			Simm	
Green 28			Simm X	Light red WF
Green 29	White 11 <u>CA</u>		Hereford	
Green 30			Char X	Yellow
Green 31	Blue 100	911110	Simm	"Rock-m-Sock-m"
Green 32	Blue W42	911103	Simm X	Carmel WF
Black 3			Here X	Brockle-face, horns
Green 33	Green 175		Char X	Grey WF
Green 34	White 14 <u>CA</u>		Hereford	
Green 35	Orange 180		Char	
Green 36	Green 154		Hereford	
Green 37	Green 159	911062		Red Brockle face
Green 38	Yellow 46U	911079	Char	
Green 39	Blue W40			Carmel
Green 40	White 184		Char	
Green 41	Green J36			Yellow Brockle face
Green 42	Orange 136X		Char	

<sup>1</sup> Tag placed in ear to identify cow on the study

<sup>2</sup> Number of existing tags present when animal was retagged

<sup>3</sup> AEC specimen identification

<sup>a</sup> Blood samples obtained (red top Vacutainers, Becton-Dickinson, Franklin, NJ) for serology

<sup>b</sup> Aborted in early December, 1993

Table 4 Ranch A Cattle Bled and Re-tagged on December 6-7, 1993 (Cont'd)

1993 Tag <sup>1</sup>	Old Tag <sup>2</sup>	ID No. <sup>3</sup>	Breed	Comments
Green 43	Blue 49R		Saler	
Green 44	White 77 <u>CA</u>		Hereford	
Green 45	Blue 170		Simm X	
Green 46	Yellow 21		Hereford	Horns
Green 47			Char X	Yellow WF
Green 48			Longhorn X	White with red ears
Green 49			Char	
Green 50	Blue 74		Angus X	Black
Green 51			Angus X	BWF
Green 52	White 181		Simm	
Green 53	Blue Z-76		Hereford	Right horn
Green 54	White 26		Char	
Green 55			Hereford	New cow Oct 1993
Green 56	Orange 170		Simm X	Blaze face
Green 57			Hereford	
Green 58	Brisket 2G		Gelbvieh	
Green 59	White 36 <u>CA</u>		Hereford	Lump on right face
Green 60			Saler X	Blaze face
Green 61	Brisket 51		Pure Char	
Green 62	White 60 <u>CA</u>		Hereford	
Green 63	Black 28		Black Angus	
Green 64			Hereford	
Green 65			Hereford	

<sup>1</sup> Tag placed in ear to identify cow on the study

<sup>2</sup> Number of existing tags present when animal was retagged

<sup>3</sup> AEC specimen identification

<sup>a</sup> Blood samples obtained (red top Vacutainers, Becton-Dickinson, Franklin, NJ.) for serology

<sup>b</sup> Aborted in early December, 1993

Table 4 Ranch A Cattle Bled and Re-tagged on December 6-7, 1993 (Cont'd)

1993 Tag <sup>1</sup>	Old Tag <sup>2</sup>	ID No. <sup>3</sup>	Breed	Comments
Green 66	Green Z-85	911075	Limo X	
Green 67	Blue X-36	911081	Simm	Blaze face
Green 68			Saler	
Green 69			Saler	
Black 4			Maine Anjou	
Black 5	Orange tag		Hereford	
Green 76	Green Z-32		Char	White face
Green 77	Blue 168		Simm	
Green 78	Blue 21		Simm	
Green 79	Green 10 Yellow 200		Char	?old cow
Green 80	White 61 YJr, 637U		Char (big)	
Green 81			Char X	Horns Carmel
Green 82			Char X	Carmel WF
Green 83	Yellow 34X (N.X.S.)		Simm X	
Green 84	White 31 CA		Hereford	
Black 6	Red 13			
Green 85			Hereford	
Green 86	White 56 CA		Hereford	
Green 87			Angus X	BWF
Green 88	Orange 46		Char X	Brockle face
Green 89			Hereford	
Green 90	Blue Z-23		Hereford	Left horn back
Green 91	Orange U-27		Hereford	
Green 92			Saler	Tall

<sup>1</sup> Tag placed in ear to identify cow on the study

<sup>2</sup> Number of existing tags present when animal was retagged

<sup>3</sup> AEC specimen identification

<sup>a</sup> Blood samples obtained (red top Vacutainers, Becton-Dickinson, Franklin, NJ.) for serology

<sup>b</sup> Aborted in early December, 1993

Table 4 Ranch A Cattle Bled and Re-tagged on December 6-7, 1993 (Cont'd)

1993 Tag <sup>1</sup>	Old Tag <sup>2</sup>	ID No. <sup>3</sup>	Breed	Comments
Green 93			Red Angus X	
Green 94	Green Y-11		Char X	Carmel WF
Green 95	Purple 31 OB	900565	Char X	Long left horn
Green 96	Orange 110W		Hereford	
Black 7	Black 18			
Green 97	Blue 39		Black Angus	Brockle face
Green 98	Green A-12		Saler	
Green 99	Yellow 190		Saler	
Green 100	Yellow 417 Yellow 201	911072	Black Angus	
Black 8			Simm	"Big bloody cow"
Black 9			Char X Black Angus	
Black 10	Black 13		Char X	Carmel
Black 11	Orange 46W		Pinzgaur X	
Green 101			Red Angus X	Red bald face
Green 102	Blue 167		Red Angus	
Green 103			Char X	Carmel bald face
Green 104	Orange P-2, 127Y		Red Angus X Brown Swiss	
Green 105	Orange 105Y		Red Angus X	Brockle face
Green 106	Orange 121X		Saler	
Green 107			Saler	Low pain tolerance
Green 108			Char X	Mouse Bald face
Green 109	White 107 CA		Simm	
Green 110				BWF
Green 111			Black Angus	Brockle face

<sup>1</sup> Tag placed in ear to identify cow on the study

<sup>2</sup> Number of existing tags present when animal was retagged

<sup>3</sup> AEC specimen identification

<sup>a</sup> Blood samples obtained (red top Vacutainers, Becton-Dickinson, Franklin, NJ.) for serology

<sup>b</sup> Aborted in early December, 1993

Table 4 Ranch A Cattle Bled and Re-tagged on December 6-7, 1993 (Cont'd)

1993 Tag <sup>1</sup>	Old Tag <sup>2</sup>	ID No. <sup>3</sup>	Breed	Comments
Green 112	Purple 16 OB	911085	Hereford	
Green 113	Purple 30 OB	911096	Black Angus	
Green 114			Simm	
Green 115			Pinzgaur	
Green 116	Green Z-29		Angus X	Brockle face
Green 117			Hereford X Jersey	Speckle face
Green 118	Green 1		Hereford	
Green 119	White 120 CA		Black Angus	Bites!
Green 120	White 110 CA		Hereford	
Green 121			Char X	Carmel
Green 122			Hereford	
Green 123	Yellow 197 Yellow <sup>3</sup> 21		Black Angus	
Green 124	White 10 CA		Simm	
Green 125	Orange 113X		Red Angus X Brown Swiss	
Green 126	Green 90		Char	
Green 127	Yellow <sup>3</sup> 22 Yellow 194		Black Angus	Big
Green 128			Char X	Carmel bald face
Green 129	Orange 14U		Hereford X	Red bald face
Green 130	Orange 13N		Hereford X	Red bald face
Green 131	Orange U-25		Char	
Green 132	Orange 114W		Hereford	
Green 133	Blue 173		Angus X	Red bald face
Green 134			Saler	

<sup>1</sup> Tag placed in ear to identify cow on the study

<sup>2</sup> Number of existing tags present when animal was retagged

<sup>3</sup> AEC specimen identification

<sup>a</sup> Blood samples obtained (red top Vacutainers, Becton-Dickinson, Franklin, NJ.) for serology

<sup>b</sup> Aborted in early December, 1993

Table 4 Ranch A Cattle Bled and Re-tagged on December 6-7, 1993 (Cont'd)

1993 Tag <sup>1</sup>	Old Tag <sup>2</sup>	ID No. <sup>3</sup>	Breed	Comments
Black 12			Hereford	
Black 13	Red 17		Hereford	
Black 14	Red 12		Simm X	Short ears
Black 15	?White 130		Hereford	Horns
Green 137	White 8 CA		Red Angus X	Brockle face
Green 138			Char X	Mouse brockle face
Green 139	Yellow 21		Red shorthorn	
Green 140	Orange 10 Yellow 191		Red Angus	Horns
Green 141			Saler	
Green 142	Yellow 20		Black Angus	
Green 143	Green 7		Simm	
Green 144	Orange U-26		Char X	Tan bald face
Green 145			Black Angus	
Green 146	Orange 117W		Hereford	
Green 147	W21 Yellow ACXB,12R,12B		Charolais (Purebred)	
Green 148			Hereford	
Green 149	RED -Harry10U		Hereford	
Green 150	White 6		Angus X	Red -white blaze
Green 151	Green 177	911065	Red Angus X Char	Red
Green 152	Green Y-8		Char X	White face
Green 153	Yellow 158		Char	
Green 154			Saler	
Green 155	Yellow 132		Hereford	

<sup>1</sup> Tag placed in ear to identify cow on the study

<sup>2</sup> Number of existing tags present when animal was retagged

<sup>3</sup> AEC specimen identification

<sup>a</sup> Blood samples obtained (red top Vacutainers, Becton-Dickinson, Franklin, NJ.) for serology

<sup>b</sup> Aborted in early December, 1993

Table 4 Ranch A Cattle Bled and Re-tagged on December 6-7, 1993 (Cont'd)

1993 Tag <sup>1</sup>	Old Tag <sup>2</sup>	ID No. <sup>3</sup>	Breed	Comments
Green 156	White 144 CA		Angus X	BWF
Green 157	White 23		Charolais (Purebred)	
Green 158	Purple 3 OB	911097	Angus X	Red -white blaze
Green 159	Orange 6E, 139Y		Char X	Mouse, white brockle
Green 160			Angus X	Red white face, red around eye
Green 161	Blue 172		Char X Black Angus	Mouse
Black 18	Black 1		Char X	Speckle face
Black 19			Hereford	horns
Black 20	Red 11		Simm X	Light tan, bald face
Black 21			Saler X	Red, white brockle
Black 22	Yellow 30 H of A BC		Longhorn	Carmel, horns
Black 23	Red Harty-100		Hereford	
Black 24	White 7		Angus X	Red - white brockle
Black 25			Char - Black Angus	
Black 31	White 6		Angus X	Red - brockle face
Black 36			Hereford	
Black 45	White 107		Simm	
Black 48			Hereford	
Black 49	Red 15		Hereford	
Green 162	Orange 22			Red brockle face
Green 163	Green A-14		Hereford	
Green 164	Brisket 3G		Charolais	

<sup>1</sup> Tag placed in ear to identify cow on the study

<sup>2</sup> Number of existing tags present when animal was retagged

<sup>3</sup> AEC specimen identification

<sup>a</sup> Blood samples obtained (red top Vacutainers, Becton-Dickinson, Franklin, NJ.) for serology

<sup>b</sup> Aborted in early December, 1993

Table 4 Ranch A Cattle Bled and Re-tagged on December 6-7, 1993 (Cont'd)

1993 Tag <sup>1</sup>	Old Tag <sup>2</sup>	ID No. <sup>3</sup>	Breed	Comments
Green 165	Green J-34		Char X	
Green 166	Orange U-47		Char	
Green 167			Char X	White face, horns
Green 168	Orange 57W	911108	Red Angus	
Green 169	White 58		Angus X	BWF
Green 170	Green 160		Hereford X	Brockle face
Green 171	Yellow 198 Yellow 327		Black Angus	
Green 172	Orange 113W		Hereford	
Green 173	Yellow 192		Black Angus	
Green 174			Angus X	BWF
Green 175	Orange 6		Charolais	
Green 176	Green 79		Char X	Carmel white face
Green 177	Orange 112W	9111087	Hereford X	Brockle face
Green 178	Brisket tag 52		Charolais	
Green 179	White 42		Black Angus	
Green 180			Hereford	
Green 181			Simm	
Green 182			Saler	Horns
Green 183			Simm	
Green 184?				
Green 185			Red Angus X Char	Carmel with horns
Green 186			Char X	Carmel white face
Green 187			Saler	

<sup>1</sup> Tag placed in ear to identify cow on the study

<sup>2</sup> Number of existing tags present when animal was retagged

<sup>3</sup> AEC specimen identification

<sup>a</sup> Blood samples obtained (red top Vacutainers, Becton-Dickinson, Franklin, NJ.) for serology

<sup>b</sup> Aborted in early December, 1993

Table 4 Ranch A Cattle Bled and Re-tagged on December 6-7, 1993 (Cont'd)

1993 Tag <sup>1</sup>	Old Tag <sup>2</sup>	ID No. <sup>3</sup>	Breed	Comments
Green 188			Angus X	BWF
Green 189			Angus X	Black, brockle face
Green 190	Blue 21		Angus X	BWF
Green 191	White 182		Red Angus X	Blaze face
Green 192	Blue 162		Hereford	Horns
Green 193	Blue 92		Char X	
Green 194	Blue 25Y		Char X	Carmel WF
Green 195	Green 24X		Char X	Carmel WF
Green 196	White 126 CA		Hereford	
Green 197	White 41		Black Angus	
Green 198	Brisket 117 Blue 171	911217	Simm	
Green 199	Green W-20		Char X	Carmel WF
Green 200			Simm	Red white strip twins last year
Green 201	Blue 161	911092	Red Angus	Blind right eye
Green 202			Hereford	
Green 203	Green X-4	911113	Char X	Carmel WF
Green 204	Orange S-38 128Y		Char X	Carmel white strip
Green 205			Simm	Tall
Green 206			Black Angus X	Brockle face
Green 207			Char	
Green 208	Yellow 116		Char	
Green 209	Blue W-34	911066	Red Angus X	Red brockle face

<sup>1</sup> Tag placed in ear to identify cow on the study

<sup>2</sup> Number of existing tags present when animal was retagged

<sup>3</sup> AEC specimen identification

<sup>a</sup> Blood samples obtained (red top Vacutainers, Becton-Dickinson, Franklin, NJ.) for serology

<sup>b</sup> Aborted in early December, 1993

Table 4 Ranch A Cattle Bled and Re-tagged on December 6-7, 1993 (Cont'd)

1993 Tag <sup>1</sup>	Old Tag <sup>2</sup>	ID No. <sup>3</sup>	Breed	Comments
Green 210	Blue 957		Char	WF
Green 211	Blue U-103		Simm X	
Green 212			Black Angus X	BWF
Green 213	Green 174	911100	Char	
Green 214	Orange U-48		Saler	
Green 215	White 143 CA		Hereford	Blunt horns
Green 216	Orange U-54		Char X	Carmel WF
Green 217	Yellow 203		Red Angus	
Green 218			Pinzgaur X	Black
Green 219	Green U-28		Black Angus	"Star"
Green 220			Black Angus X	BWF
Green 221	Green 158	911056	Bl Angus X Shorthorn	"Blueberry"
Green 222			Simm X	WF
Green 223			Limo	Red
Green 224	Green U-130	911080	Hereford	

<sup>1</sup> Tag placed in ear to identify cow on the study

<sup>2</sup> Number of existing tags present when animal was retagged

<sup>3</sup> AEC specimen identification

<sup>a</sup> Blood samples obtained (red top Vacutainers, Becton-Dickinson, Franklin, NJ.) for serology

<sup>b</sup> Aborted in early December, 1993

hardjo. Positive leptospirosis titers (1:200 or 1:400) against the serovar *sejroe* were detected in serum samples from cows, Nos. 900568, 930596, 930600, 930595, 900548, 900553.

The trace nutrient results for December 6 are listed in Table 6. The mean plasma Se concentration was 118 ng/mL (n=21) with a range of 34 through 197 ng/mL. The mean blood selenium concentration was 210 ng/mL (n=21) with a range of 40 through 386 ng/mL. Whole blood Se greater than 70 ng/mL is considered a normal Se status (Maas *et al.*, 1996). Cow No. 930593 had a deficient selenium status. The mean copper concentration was 1006 ng/mL (n=21) with a range of 232 through 1971 ng/mL. While liver copper concentration are the best indicators of copper status in a herd, cows with plasma concentrations less than 700 ng/mL are considered

Table 5 Ranch A Cattle Serology<sup>a</sup> from December 6-7, 1993 Samples

ID No.	IBR <sup>b</sup> titer	BVD <sup>c</sup> titer	<i>Leptospirosis</i> titer (serovar) <sup>d</sup>
900566	1:46	≥ 1:256	negative
900567	1:52	≥ 1:256	negative
900568	1:45	≥ 1:256	sejroe positive 1:400
900569	1:77	≥ 1:256	negative
930596	1:51	≥ 1:256	sejroe positive 1:200
930597	1:74	≥ 1:256	negative
930598	1:78	≥ 1:256	negative
930600	1:59	≥ 1:256	sejroe positive 1:200
930603	1:6	≥ 1:256	negative
930605	1:46	≥ 1:256	negative
930607	1:28	≥ 1:256	negative
930608	1:44	≥ 1:256	negative
930610	1:54	≥ 1:256	negative
930595	1:22	≥ 1:256	sejroe positive
930601	1:68	≥ 1:256	negative
900397	1:44	≥ 1:256	negative
900548	1:78	≥ 1:256	sejroe positive 1:400
900553	1:68	≥ 1:256	sejroe positive 1:200
930599	1:50	≥ 1:256	negative
930593	1:7	≥ 1:256	negative
930594	1:37	≥ 1:256	negative

<sup>a</sup> Test results from Palliser Animal Health Laboratories, LTD, Lethbridge, AB

<sup>b</sup> Infectious Bovine Rhinotracheitis (IBR)

<sup>c</sup> Bovine Virus Diarrhea (BVD) virus; BVD virus not isolated

<sup>d</sup> *Leptospira pomona, ictero, canicola, copenhagenii, grippotyphosa, bratislava, hardjo and sejroe*

Table 6 Ranch A Peripheral Blood (B) or Plasma (P) Trace Nutrient Status of Cows for Selenium (Se), Copper (Cu) and Vitamin E

AEC NO.	Bled 93/12/06			Bled 94/01/20
	P Se	B Se	P Cu	
930599	67 ng/mL	177 ng/mL	1288 ng/mL	a
930593	34 ng/mL	40 ng/mL	1294 ng/mL	
900553	61 ng/mL	151 ng/mL	542 ng/mL	P Se 149 ng/mL P Cu 1028 ng/mL Vit E 3.1 µg/mL
900568	161 ng/mL	230 ng/mL	1172 ng/mL	a
930594	150 ng/mL	200 ng/mL	1757 ng/mL	a
930596	56 ng/mL	137 ng/mL	1242 ng/mL	P Se 148 ng/mL P Cu 575 ng/mL Vit E 3.4 µg/mL
930597	157 ng/mL	239 ng/mL	943 ng/mL	a
930598	148 ng/mL	255 ng/mL	1196 ng/mL	a
900566	81 ng/mL	137 ng/mL	1294 ng/mL	a
900548	92 ng/mL	206 ng/mL	1971 ng/mL	P Se 78 ng/mL P Cu 528 ng/mL Vit E 1.9 µg/mL
900567	105 ng/mL	193 ng/mL	486 ng/mL	P Se 299 ng/mL P Cu 555 ng/mL Vit E 3.3 µg/mL

<sup>a</sup> Blood taken but not analysed

Table 6 Ranch A Peripheral Blood (B) or Plasma (P) Trace Nutrient Status of Cows for Selenium (Se), Copper (Cu) and Vitamin E (Cont'd)

AEC NO.	Bled 93/12/06	Bled 94/01/20
900569	P Se 177 ng/mL B Se 262 ng/mL P Cu 1032 ng/mL	P Se 156 ng/mL P Cu 636 ng/mL Vit E 2.6 µg/mL
900397	P Se 97 ng/mL B Se 201 ng/mL P Cu 232 ng/mL	a
930600	P Se 178 ng/mL B Se 250 ng/mL P Cu 682 ng/mL	a
930602		P Se 472 ng/mL P Cu 465 ng/mL Vit E 3.2 µg/mL
930603	P Se 124 ng/mL B Se 179 ng/mL P Cu 867 ng/mL	P Se 100 ng/mL P Cu 733 ng/mL Vit E 3.4 µg/mL
930605	P Se 93 ng/mL B Se 158 ng/mL P Cu 1467 ng/mL	P Se 456 ng/mL P Cu 651 ng/mL Vit E 3.0 µg/mL
930607	P Se 94 ng/mL B Se 144 ng/mL P Cu 1770 ng/mL	a
930608	P Se 142 ng/mL B Se 254 ng/mL P Cu 565 ng/mL	a
930610	P Se 197 ng/mL B Se 285 ng/mL P Cu 358 ng/mL	P Se 264 ng/mL P Cu 562 ng/mL Vit E 2.8 µg/mL
940047		P Se 78 ng/mL P Cu 827 ng/mL Vit E 3.7 µg/mL
940051		P Se 82 ng/mL P Cu 813 ng/mL Vit E 2.8 µg/mL

<sup>a</sup> Blood taken but not analyzed

Table 6 Ranch A Peripheral Blood (B) or Plasma (P) Trace Nutrient Status of Cows for Selenium (Se), Copper (Cu) and Vitamin E (Cont'd)

AEC NO.	Bled 93/12/06			Bled 94/01/20		
	P Se	542 ng/mL	P Cu	636 ng/mL	Vit E	2.9 µg/mL
940053						
940049						
911080						
930595	P Se B Se P Cu	109 ng/mL 386 ng/mL 704 ng/mL			P Se P Cu Vit E	378 ng/mL 746 ng/mL 3.1 µg/mL
930601	P Se B Se P Cu	174 ng/mL 332 ng/mL 274 ng/mL			P Se P Cu Vit E	381 ng/mL 744 ng/mL 2.2 µg/mL
940048					P Se P Cu Vit E	450 ng/mL 582 ng/mL 3.1 µg/mL
930606						a
940050						a
900570						a
930609						a
930604						a
911084						a
Summary:	P Se n=21	34 118 197	Min Mean Max	P Se n=17	78 273 542	Min Mean Max

<sup>a</sup> Blood taken but not analysed

Table 6 Ranch A Peripheral Blood (B) or Plasma (P) Trace Nutrient Status of Cows for Selenium (Se), Copper (Cu) and Vitamin E (Cont'd)

	B Se N=21	40 210 386	Min Mean Max	Vit E N=17	1.9 2.9 3.7	Min Mean Max
	P Cu N=21	232 1006 1971	Min Mean Max	P Cu N=17	465 689 1028	Min Mean Max

<sup>a</sup> Blood taken but not analysed

to have an inadequate copper status (Maas and Smith, 1996). Cow Nos. 900553, 900567, 900397, 930600, 930608, 930610, and 930601 had lower plasma copper concentrations.

The frozen, aborted fetuses were necropsied on December 8. Fetus, ID No. 930565, was aborted by cow No. 930593 (Y38) and fetus, ID No. 930566, was aborted by cow No. 930599 (OR2). The gross examinations are provided in Appendix B. Briefly, male calf No. 930565 weighed 9 kg with a crown-rump length of 60 cm. The calf had hair around the eyes and muzzle, and appeared autolyzed. The virus isolation and fluorescent antibody (FA) tests against IBR and BVD and viruses and diagnostic immunohistochemistry tests against Bovine Herpes Virus Type 1 and BVD virus on tissue sections were negative. The liver Se concentration, 724 ng/g, reflects an inadequate Se status for fetuses (Puls, 1990). The liver Cu concentration of 145 µg/g indicates an adequate Cu status (Puls, 1990).

The cause of the abortion could not be determined by histopathology (Stair and Kosanke, 1997). The histopathological diagnosis on calf No. 930565 follows:

- (1) Intrauterine immunostimulation; the cause could not be determined by histopathology
- (2) Vacuolar hepatocellular degeneration
- (3) Retention of bile within biliary canaliculi
- (4) Bile duct aplasia.

Male calf No. 930566 weighed 14.5 kg with a crown-rump length of 68 cm. The calf had hair around the eyes and muzzle, and a multi-chambered cyst on the posterior aspect of the liver that was filled with a blood-tinged fluid. The virus isolation and FA tests against IBR and BVD and viruses and diagnostic immunohistochemistry tests against Bovine Herpes Virus Type 1 and BVD virus on tissue sections were negative. The liver Se concentration of 1.2 µg/g reflects an

inadequate Se status for fetuses (Puls, 1990). The liver Cu concentration of 145 µg/g indicates an adequate Cu status (Puls, 1990).

The postmortem autolysis was advanced in most tissue and would have obscured any lesions that might have been present (Stair and Kosanke, 1997). The cause of death and abortion could not be determined by histopathology. The histopathological diagnosis on calf No. 930566 follows:

- (1) Hepatocellular fatty change
- (2) Brain, petechial hemorrhages.

The Ranch A cattle herd on the east pastures consisted of approximately 260 cows that were fed six large round bales (1500 pounds) of hay and two large round bales of oat greenfeed on a daily basis. The forage analyses of composite samples of hay (ID No. 930591) and greenfeed (ID No. 930592) are listed in Table 7. On a dry matter basis, the hay and greenfeed had a protein level of 6.1% and 6.4%, respectively, and TDN estimates of 46% and 41%, respectively. The mineral concentrations for Cu were 5.6 µg/g and 3.7 µg/g, for zinc (Zn) were 20.1 µg/g and 15.2 µg/g, for sulfur (S) were 0.09% and 0.12%, and for molybdenum (Mo) were 1.9 µg/g and 1.5 µg/g, respectively. The Cu concentrations were low. Maas and Smith (1996) consider pasture forage Cu concentrations of 3 to 5 µg/g to be marginal in preventing a primary Cu deficiency. The recommended concentration of Cu in a beef cow diet is 10 mg/kg of diet provided that the diet contains less than 0.25% S and less than 2 mg Mo per kg of diet (NRC, 1996). The cows were fed a mineral supplement Weatherguard™ Cattle Range Mineral No. 2 with selenium (Table 8) *ad libitum*, mixed with loose salt.

### 7.3 Field Investigations - 1994

January 18-21, 1994. On January 19, 1994, the field team of M. Mostrom and C. Campbell met with the consulting veterinarian for the petroleum company who was evaluating livestock in the vicinity of the pipeline leak. The consulting veterinarian provided information on the initial exposure, an overview of the concerns of local livestock owners, and clinical signs observed or reported in animals after the pipeline leak (Mostrom, 1994b). Briefly, the cattle owners were concerned about possible water contamination, livelihood, and reputation as a cattle producer if a high mortality occurs, and the long-term situation. The producers wanted livestock monitoring by

Table 7 Analyses of Forages from Ranch A and Ranch B (1993-1994)

Ranch A	Unit	Sample No. 930591		Sample No. 930592		Sample No. 940043	
		Hay (93.12.06)		Greenfeed (93.12.06)		Hay Timothy (94.01.21)	
		As	Dry	As Fed	Dry	As Fed	Dry
Calcium	%	0.35	0.40	0.33	0.38	0.50	0.60
Phosphorus	%	0.07	0.08	0.12	0.14	0.13	0.16
Zinc	µg/gm	17.7	20.1	13.2	15.2	19.8	23.7
Copper	µg/gm	4.93	5.58	3.20	3.68	4.14	4.96
Magnesium	%	0.09	0.10	0.11	0.12	0.11	0.14
Manganese	µg/gm	16.7	18.9	23.6	27.1	20.5	24.6
Sulfur	%	0.08	0.09	0.11	0.12	0.10	0.13
Molybdenum	µg/gm	1.64	1.9	1.27	1.5	3.06	3.7
Salt	%	<0.02	<0.03	0.17	0.20	<0.02	<0.03
Potassium	%	0.99	1.12	1.00	1.15	1.36	1.63
Sodium	%	<0.01	0.01	0.07	0.08	<0.01	0.01
Iron	µg/gm	55.4	62.7	89.5	103	123	147
TDN Estimate	%	40.9	46.4	35.4	40.6	46.6	55.9
Protein	%	5.38	6.10	5.54	6.36	7.32	8.77
Moisture 110 C	%	11.7		13.0		16.5	
ADI Nitrogen	%	0.197	0.223	0.158	0.181	0.192	0.230
Cobalt	µg/gm	0.64	0.7	0.65	0.7	<0.60	0.6
Digestible Energy	Mcal/kg	2.2	2.4	2.0	2.4	2.2	2.6
Available Protein	%	4.15	4.70	4.55	5.23	6.12	7.33
ADI Protein%	%	1.23	1.39	0.99	1.13	1.20	1.43
Net Energy for Lactation	Mcal/kg	0.7	0.8	0.6	0.6	0.9	1.1
Net Energy for Gain	Mcal/kg	0.3	0.3	0.1	0.1	0.4	0.5
Net Energy for Maintenance	Mcal/kg	1.0	1.0	0.8	0.8	1.1	1.2
Fiber (ADF)	%	40.3	45.6	43.0	49.4	32.8	39.2
Digestible Energy	Mcal/lb	1.0	1.1	0.9	1.1	1.0	1.2
Selenium	mg/kg						0.07 <sup>a</sup>

Norwest Labs, Feed Analysis Report, Edmonton, AB

<sup>a</sup> Feed Testing Service, University of Saskatchewan, Saskatoon, SK, Canada

Table 7 Analyses of Forages from Ranch A and Ranch B (1993-1994) (Cont'd)

		Sample No. 940125	Sample No. 940041		Sample No. 940042	
Ranch B	Unit	Silage (94.02.08)	Hay Timothy/Alfalfa (94.01.21)		Hay Alfalfa/Timothy (94.01.21)	
			As Fed	Dry	As Fed	Dry
Calcium	%		0.41	0.49	0.65	0.78
Phosphorus	%		0.07	0.09	0.11	0.13
Zinc	µg/gm		13.0	15.4	17.8	21.4
Copper	µg/gm		3.20	3.81	3.58	4.30
Magnesium	%		0.10	0.12	0.13	0.15
Manganese	µg/gm		20.7	24.6	21.3	25.6
Sulfur	%		0.07	0.08	0.08	0.09
Molybdenum	µg/gm		<1.00	<1.0	<1.00	1.2
Salt	%		<0.02	<0.03	<0.02	<0.03
Potassium	%		1.10	1.31	1.49	1.79
Sodium	%		<0.01	0.01	<0.01	0.01
Iron	µg/gm		15.2	18.1	25.5	30.6
TDN Estimate	%		42.3	50.4	42.1	50.6
Protein	%		5.60	6.67	6.83	8.21
Moisture 110 C	%	64.23	16.0		16.9	
ADI Nitrogen	%		0.165	0.197	0.199	0.239
Cobalt	µg/gm		<0.60	0.6	<0.60	0.6
Digestible Energy	Mcal/kg		2.1	2.5	2.1	2.5
Available Protein	%		4.57	5.44	5.58	6.72
ADI Protein%	%		1.03	1.23	1.24	1.49
Net Energy for	Mcal/kg		0.8	1.0	0.8	1.0
Net Energy for Gain	Mcal/kg		0.3	0.4	0.4	0.4
Net Energy for	Mcal/kg		1.0	1.1	1.1	1.1
Fiber (ADF)	%		36.1	42.9	36.5	43.9
Digestible Energy	Mcal/lb		1.0	1.1	0.9	1.1
Selenium	mg/kg	0.09 <sup>a</sup>		0.04 <sup>a</sup>		0.06 <sup>a</sup>

Norwest Labs, Feed Analysis Report, Edmonton, AB

<sup>a</sup>(Dry-weight basis) Feed Testing Service, University of Saskatchewan, Saskatoon, SK, Canada

Table 7      Analyses of Forages from Ranch A and Ranch B (1993-1994) (Cont'd)

		Sample No. 940694		Sample No. 940695	
Ranch A	Unit	Hay - 1994 (94.12.01)		Hay - 1993 (94.12.01)	
		Dry	As Fed	Dry	As Fed
Calcium	%	0.61	0.52	0.56	0.46
Phosphorus	%	0.18	0.15	0.16	0.13
Zinc	µg/gm	18.8	16.1	22.9	19.1
Copper	µg/gm	5.74	4.93	4.42	3.69
Magnesium	%	0.13	0.11	0.13	0.10
Manganese	µg/gm	24.7	21.2	26.2	21.9
Sulfur	%	0.13	0.11	0.12	0.10
Molybdenum	µg/gm				
Salt	%	0.03	0.03	0.03	0.02
Potassium	%	1.73	1.49	1.42	1.18
Sodium	%	0.01	0.01	0.01	<0.01
Iron	µg/gm	50.1	43.0	61.4	51.2
TDN Estimate	%	43.9	37.7	44.1	36.9
Protein	%	9.16	7.86	8.19	6.84
Moisture 104 C	%		14.1		16.5
ADI Nitrogen	%	0.217	0.186	0.193	0.161
Cobalt	µg/gm				
Digestible Energy	Mcal/k	2.3	2.0	2.3	2.0
Available Protein	%	7.80	6.70	6.98	5.83
ADI Protein%	%	1.36	1.16	1.21	1.01
Net Energy for Lactation	Mcal/k	0.8	0.7	0.8	0.7
Net Energy for Gain Mcal/kg	Mcal/k	0.3	0.2	0.3	0.2
Net Energy for Maintenance	Mcal/k	1.0	0.9	1.0	0.9
Fiber (ADF)	%	50.5	43.3	50.2	41.9
Digestible Energy	Mcal/lb	1.1	0.9	1.1	0.9
Selenium	mg/kg				

Norwest Labs, Feed Analysis Report, Edmonton, AB

<sup>a</sup>Feed Testing Service, University of Saskatchewan, Saskatoon, SK, Canada

Table 8      Ingredient List of Weatherguard™ Cattle Range Mineral

Weatherguard™ Cattle Range Mineral No. 2 18-12-0 (Se)	
Calcium (act.)	18.0%
Phosphorus (act.)	12.0%
Magnesium (act.)	1.0%
Potassium (act.)	0.1%
Sulfur (act.)	0.2%
Fluorine (max.)	3000 mg/kg
Iron (act.)	5000 mg/kg
Zinc (act.)	8000 mg/kg
Manganese (act.)	9600 mg/kg
Copper (act.)	4000 mg/kg
Iodine (act.)	500 mg/kg
Cobalt (act.)	50 mg/kg
Vitamin A (min.)	500,000 IU/kg
Vitamin D <sub>3</sub> (min.)	50,000 IU/kg
Vitamin E (min.)	750 IU/kg

Calcium phosphate monobasic, calcium phosphate tribasic (defluorinated), ammonium phosphate monobasic, limestone ground, potassium and magnesium sulfate, magnesium oxide, potassium chloride, ferrous carbonate, ferric oxide, zinc oxide, manganous oxide, copper sulfate, calcium iodate, cobalt carbonate, sodium selenite, yeast culture dehydrated, molasses, vitamin A, vitamin D<sub>3</sub>, vitamin E, mineral oil, vegetable oil, ethoxyquin, flavouring agents. This feed contains added selenium at 30.0 mg/kg. Manufactured by PMT Inc., Regina, SK.

the petroleum company, which was provided to livestock producers in the vicinity of the pipeline leak.

The earliest the pipeline leak might have occurred was reportedly January 6. [Some cattle producers, including the owner of Ranch A who pastured cattle adjacent to the leak, reportedly smelled H<sub>2</sub>S/condensate odors prior to January 6]. A majority of the air monitoring concentrations in the vicinity around the leak were less than 20 ppm, although a reading of 140 ppm H<sub>2</sub>S was detected near a pool of condensate on ice. Following the ignitions, the first smoke plume (January 8) reportedly traveled along the Red Deer River ridge and the second smoke plume (January 11)

went up and south. Some air monitoring was repeatedly performed on the second plume using helicopter transportation.

Following the discovery of the pipeline leak, numerous individuals complained of a heavy condensate odor. The location of livestock in proximity to the leak site and problems observed or reported in livestock were discussed. Some of the cattle had epiphora on January 11 and 12, but the consulting veterinarian was uncertain if the problem was related to petroleum emissions. The potential effect of weather or cold temperatures on clinical signs was a factor to consider in the health evaluations. A summary of the 1994 cold weather data is provided in Appendix C. For comparison purposes, the 1988 weather data (a similarly cold year) were included.

On January 19, the field team met with the manager and an engineer from the petroleum complex. An overview of the pipeline leak incident, emergency responses, and approach to the clean-up procedures of the spill were provided.

The purpose of the January 20 field investigation of Ranch A was to follow-up on the initial clinical evaluations made by the consulting veterinarian, to clinically evaluate the entire herd of cows, and to body condition score (BCS) the cows. A majority of the approximately 320-cow herd was processed through the cattle handling facility. The cattle were clinically evaluated and a body condition score (BCS) was determined (Table 9). About 20 cows, kept on a pasture near the ranch house, were not processed or examined. The BCS for beef cattle was based on a 10 point score system; a score of *medium* -- represented a 3 out of 9, a *medium* - represented a 3.5 to 4 out of 9, a *medium* + represented a 5, and *good* represented a 6 to 7 out of 9. No scores of 1 or 2 (emaciated) and 8 or 9 (fat to very fat) were given. Some of the cattle bled on December 6, 1993 were re-bled for trace nutrient analyses (Table 6). The Ranch A owner vaccinated the cows with ScourGuard 3(K)/C (SmithKline Beecham Animal Health, West Chester, PA) and a clostridium/*Haemophilus somnus* product (Fermicon 7/Somnugen, Boehringer Ingelheim Animal Health Inc., St. Joseph, MO), injected the cows with 6 mL Dystosel, and pouched on cows and late calves with Lysoff (Cutter Animal Health, Rexdale, ON).

Most of the Ranch A cow herd was pastured on 200 acres within 0.5 kilometers of the location of the pipeline leak in early January. Within four days of the pipeline leak, the owner reported that several cows displayed epiphora and two cows had conjunctivitis. One cow had vaginal discharge, was depressed and ataxic. A week post-leak, the owner reported that several

Table 9 Field Evaluations of Ranch A Cattle on January 20, 1994

1993 Tag	Old Tag	ID No.	Breed	Type	Bled 93/12/06	Bled 94/01/20	Body Condition Score 94/01/20
	Orange R2 <sup>a</sup>	930599	Angus X	Red bald face	b	c	Med +
	Yellow 38Y <sup>a</sup>	930593	Simm X	Mouse WF	b		
Green 1	White 8	900553			b	b	Good
Green 2	Orange 4	900568	Simm		b	c	Good
Green 3	Y 202	930594	Saler	Red on NW2	b	c	Med +
Green 4		930596		Hydrocarbons- had twins	b	b	Good
Green 5		930597	Angus	Black -Amber's milk cow	b	c	Med +
Green 6	Yellow 188	911084	Saler	Mate to G3 on NW2	b	c	Good
Green 7	K 53	930598	Angus X	BWF. 15 years		c	Med -
Green 8	Orange 1	900566	Simm	Hydrocarbons	b	c	Good
Green 9	White 3	900548		Control cow	b	b	Good
Green 10	Orange 2	900567	Simm	Hydrocarbons Brisket 5	b	b	Good, little lice
Green 11	Orange 6	900569	Simm	Brisket 7G	b	b	Med +
Green 12	Blue 99	900397	Simm	Hydrocarbons	b	c	Good
Green 13		930600	Angus	Black, old cow	b	c	Good
Green 14		930602	Angus	Red	b	b	Good
Green 15		930603	Angus	Black		b	Good
Green 16		930604	Simm X	Mouse WF, old		c	Med -
Green 17	132 X	930605		Old cow	b	b	Good
Green 18		930607		Red roan	b	c	Med +
Green 19		930608		Red	b	c	Med +, normal appearance
Green 20	Green 49Z	930609	Saler			c	Med+
Green 21	Green 5Y	930610	Simm X		b	b	Good
Green 22		940047	Hereford			b	Good
Green 23	Green M8		Hereford				Med +

<sup>a</sup> Aborted December 2, 1993

<sup>b</sup> Bled and analysed

<sup>c</sup> Bled but not analysed

Table 9 Field Evaluations of Ranch A Cattle on January 20, 1994 (Cont'd)

1993 Tag	Old Tag	ID No.	Breed	Type	Bled 93/12/06	Bled 94/01/20	Body Condition Score 94/01/20
Green 24	White 113 <u>CA</u>		Hereford				Good, minor ocular discharge
Green 25	Blue B25		Char	Tan			Med -, lice
Green 26	Orange J54		Angus	Black			Good
Green 27			Simm				Med+, eyes normal
Green 28			Simm X	Light red WF			Good
Green 29	White 11 <u>CA</u>		Hereford				Good
Green 30			Char X	Yellow			Good
Green 31	Blue 100	911110	Simm	Rock-m-Sock-			Good
Green 32	Blue W42	911103	Simm X	Carmel WF			Good
Green 33	Green 175		Char X	Grey WF			Med +
Green 34	White 14 <u>CA</u>		Hereford				Good
Green 35	Orange 180		Char				Good
Green 36	Green 154		Hereford				Good
Green 37	Green 159	911062	Here X	Red Brockle			Good, lice
Green 38	Yellow 46U	911079	Char				Med +
Green 39	Blue W40		Char X	Carmel			Good
Green 40	White 184		Char	White			Good
Green 41	Green J36		Char	Yellow Brockle face			Med +
Green 42	Orange 136X						Med +
Green 43	Blue 49R		Saler				Good
Green 44	White 77 <u>CA</u>		Hereford				Good
Green 45	Blue 170		Simm X				Good
Green 46	Yellow 21		Hereford	Horns			Med -
Green 47			Char X	Yellow WF			Med +
Green 48			Longhor	White with red			Med +
Green 49			Char				Good
Green 50	Blue 74		Angus X	Black			Good
Green 51			Angus X	BWF			Good

<sup>a</sup> Aborted December 2, 1993

<sup>b</sup> Bled and analysed

<sup>c</sup> Bled but not analysed

Table 9

Field Evaluations of Ranch A Cattle on January 20, 1994 (Cont'd)

1993 Tag	Old Tag	ID No.	Breed	Type	Bled 93/12/06	Bled 94/01/20	Body Condition Score 94/01/20
Green 52	White 181		Simm	RWF, Line Back			Good
Green 53	Blue Z-76		Simm X	Right horn			Good
Green 54	White 26		Char	White			Good
Green 55			Hereford	New Cow Oct			Med +
Green 56	Orange 170		Simm X	Blaze face			Med -
Green 57	Brisket 2G		Simm X	RWF			Good
Green 58			Gelbvieh				Good
Green 59	White 36 <u>CA</u>		Hereford	Lump on right			Good
Green 60			Saler X	Blaze face			Med +
Green 61	Brisket 51		Pure				Med +
Green 62	White 60 <u>CA</u>		Hereford				Good, right eye nictitating membrane inflammation & ulcer
Green 63	Black 28		Black Angus				Med -, not coughing
Green 64			Hereford				Med +
Green 65			Hereford				Good
Green 66	Green Z-85	911075	Limo X				Good, normal appearance
Green 67	Blue X-36	911081	Simm	Blaze face			Good
Green 68			Saler				Good
Green 69			Saler				Good
Green 70	White 5		Char X	White face			Good
Green 71	Green 152	911057	Char X	Horns			Good
Green 72			Bl Angus X	BWF - horns			Good
Green 73			Bl Angus	BWF			Good

<sup>a</sup> Aborted December 2, 1993

<sup>b</sup> Bled and analysed

<sup>c</sup> Bled but not analysed

Table 9 Field Evaluations of Ranch A Cattle on January 20, 1994 (Cont'd)

1993 Tag	Old Tag	ID No.	Breed	Type	Bled 93/12/06	Bled 94/01/20	Body Condition Score 94/01/20
Green 74			Char X	White face			Good
Green 75	Blue 15			BWF -bought '93			Good
Green 76	Green Z-32		Char	White face			Med +, eyes & nares appear
Green 77	Blue 168		Simm				Med -
Green 78	Blue 21		Simm				Good
Green 79	Green 10 Yellow 200		Char	?old cow			Good
Green 80	White 61 YJr, 637U		Char (big)				Good
Green 81			Char X	Horns Carmel			Good
Green 82			Simm X	Carmel WF			Good
Green 83	Yellow 34X (N.X.S.)	940049	Simm X	RWF		<sup>b</sup>	Med +, slight off gait - "dog tracking" (palpitated about 2 months prior from calving)
Green 84	White 31 CA		Hereford				Med +
Green 85			Hereford				Good
Green 86	White 56 CA		Hereford	RWF			Good
Green 87			Angus X	BWF			Good
Green 88	Orange 46		Char X	Brockle face			Good
Green 89			Hereford				Med +
Green 90	Blue Z-23		Hereford	Left horn back			Med +
Green 91	Orange U-27		Simm	Tall			Good
Green 92			Saler				Med +
Green 93			Red				Good

<sup>a</sup> Aborted December 2, 1993

<sup>b</sup> Bled and analysed

<sup>c</sup> Bled but not analysed

Table 9 Field Evaluations of Ranch A Cattle on January 20, 1994 (Cont'd)

1993 Tag	Old Tag	ID No.	Breed	Type	Bled 93/12/06	Bled 94/01/20	Body Condition Score 94/01/20
Green 94	Green Y-11		Char X	Carmel WF			Good
Green 95	Purple 31	900565	Char X	Long left horn			Med +, lice
Green 96	Orange		Hereford	RWF			Good
Green 97	Blue 39		Black	Brockle face			Med +
Green 98	Green A-12		Saler				Med +
Green 99	Yellow 190		Saler				Med -
Green 100	Yellow 417	911072	Black				Good
	Yellow 201		Angus				
Green 101	Blue 167		Red	Red bald face			Good
Green 102			Angus X				Good
Green 103			Red				Good
Green 104	Orange P-2,		Angus	Char X	Carmel bald		Good
	127X		Brown				Good
Green 105	Orange		Red	Red	Brockle face		Good
	105Y		Angus X				
Green 106	Orange	940050	Saler				Good, normal temperature, RR, HR
	121X						
Green 107			Saler	Low pain			Good
Green 108			Char X	Mouse Bald			Med +
Green 109	White 107		Simm				Good
Green 110			Here X	BWF			Good
Green 111			Black	Brockle face			Good
Green 112	Purple 16	911085	Hereford	Old cow			Good
Green 113	Purple 30	911096	Black				Good
Green 114	<u>OB</u>		Angus				Med +, lice
Green 115			Simm				
			Pinzgaur				Good

a Aborted December 2, 1993

b Bled and analysed

c Bled but not analysed

Table 9 Field Evaluations of Ranch A Cattle on January 20, 1994 (Cont'd)

1993 Tag	Old Tag	ID No.	Breed	Type	Bled 93/12/06	Bled 94/01/20	Body Condition Score 94/01/20
Green 116	Green Z-29		Angus X	Brockle face			Good, normal appearance
Green 117			Hereford	Speckle face			Good
Green 118	Green 1		Hereford				Med +
Green 119	White 120		Black	Bites!			Good
Green 120	White 110		Hereford	RWF			Good
Green 121			Char X	Carmel			Good
Green 122			Hereford	RWF			Good
Green 123	Yellow 197		Black				Med +
	Yellow 321		Angus				
Green 124	White 10 <u>CA</u>		Simm				Good
Green 125	Orange 113X		Red				Med +
			Angus X				
			Brown				
Green 126	Green 90		Char	White			Good
Green 127	Yellow 322		Black	Big			Good
Green 128	Yellow 194		Angus	Carmel bald			Good
Green 129	Orange 14U		Hereford	Red bald face			Good
Green 130	Orange 13N		Hereford	Red bald face			Good
Green 131	Orange U-25		Char	Light yellow			Good
Green 132	Orange		Hereford				Good
Green 133	Blue 173		Angus X	Red bald face			Good
Green 134			Saler				Med +
Green 135			Char	Big cow -			Good
Green 136	Blue 21		Red				Good
Green 137	White 8 <u>CA</u>		Red	Brockle face			Good
Green 138			Char X	Mouse brockle			Good
Green 139	Yellow 21		Red				Med +
Green 140	Orange 10		Red				Med -
	Yellow 191		Angus	Horns			
Green 141	Yellow 20		Saler				Med +

<sup>a</sup> Aborted December 2, 1993

<sup>b</sup> Bled and analysed

<sup>c</sup> Bled but not analysed

Table 9

Field Evaluations of Ranch A Cattle on January 20, 1994 (Cont'd)

1993 Tag	Old Tag	ID No.	Breed	Type	Bled 93/12/06	Bled 94/01/20	Body Condition Score 94/01/20
Green 142			Black				Med +
Green 143	Green 7		Simm				Good, lice
Green 144	Orange U-26		Char X	Tan bald face			Med +, lice
Green 145			Black				Good
Green 146	Orange		Hereford				Med +
Green 147	W21		Charolais				Good
	Yellow		Purebred				
Green 148			Hereford				Good
Green 149	RED -		Hereford				Good
Green 150	White 6		Angus X	Red -white			Good
Green 151	Green 177	911065	Red	Red			Good
			Angus X				
Green 152	Green Y-8		Char X	White face			Good, lice
Green 153	Yellow 158		Char	Yellow white			Good
Green 154			Saler				Good
Green 155	Yellow 132		Hereford	BWF			Good
Green 156	White 144 <u>CA</u>		Angus X				Med +
Green 157	White 23		Charolais				Med +
			Purebred				
Green 158	Purple 3 <u>OB</u>	911097	Angus X	Red -white blaze			Good, sore right front - hoof crack
Green 159	Orange 6E, 139Y		Char X	Mouse, white brockle			Med +
Green 160			Angus X	Red white face. red			Good
Green 161	Blue 172		Char X Angus	Mouse			Good

<sup>a</sup> Aborted December 2, 1993

<sup>b</sup> Bled and analysed

<sup>c</sup> Bled but not analysed

Table 9 Field Evaluations of Ranch A Cattle on January 20, 1994 (Cont'd)

1993 Tag	Old Tag	ID No.	Breed	Type	Bled 93/12/06	Bled 94/01/20	Body Condition Score 94/01/20
Green 162	Orange 22			Red brockle face			Good, tearing left eye not inflamed
Green 163	Green A-14		Hereford				Good, lice
Green 164	Brisket 3G		Charolais	White			Good, normal appearance
Green 165	Green J-34	911102	Char X				Good, normal
Green 166	Orange U-47		Char	White			Med -
Green 167			Char X	White face,			
Green 168	Orange 57W	911108	Red Angus	BWF			Good
Green 169	White 58		Angus X				Good
Green 170	Green 160		Hereford	Brockle face			Good
Green 171	Yellow 198		Black				Good
	Yellow 327		Angus				
Green 172	Orange		Hereford				Good
Green 173	Yellow 192		Black				Med +
Green 174		940051	Angus X	BWF		<sup>b</sup>	Good, large uterus - not in calf
Green 175	Orange 6		Charolais	Mousy			Good
Green 176	Green 79		Char X	Carmel white			Good
Green 177	Orange 112W	911087	Hereford X small	Brockle face			Good
Green 178	Brisket tag 52		Charolais				Med +
Green 179	White 42		Black				Good
Green 180			Hereford				Good
Green 181			Simm				Good

<sup>a</sup> Aborted December 2, 1993

<sup>b</sup> Bled and analysed

<sup>c</sup> Bled but not analysed

Table 9

Field Evaluations of Ranch A Cattle on January 20, 1994 (Cont'd)

1993 Tag	Old Tag	ID No.	Breed	Type	Bled 93/12/06	Bled 94/01/20	Body Condition Score 94/01/20
Green 182			Saler	Horns			Med -
Green 183			Hereford	RWF			Good
Green 184			Simm X Hereford	RWF			Good
Green 185			Red Angus X Char	Carmel with horns			Good
Green 186			Char X	Carmel white			Good
Green 187			Saler				Good, lice
Green 188			Angus X	BWF			Good
Green 189			Angus X	Black, brockle			Good
Green 190	Blue 21		Angus X	BWF			Good
Green 191	White 182		Red	Blaze face			Med +
Green 192	Blue 162		Small Hereford	Horns			Good
Green 193	Blue 92		Char X				Good
Green 194	Blue 25Y		Char X	Carmel WF			Good
Green 195	Green 24X		Char X	Carmel WF			Good, lice
Green 196	White 126		Hereford				Good
Green 197	White 41	911217	Black				Med +
Green 198	Brisket 117 Blue 171		Angus				Good
Green 199	Green W-20		Simm				Good, eyes normal
Green 200			Char X	Carmel WF			Good
Green 201	Blue 161	911092	Red	Red white strip			
Green 202			Hereford	twins last year			
Green 203	Green X-4	911113	Char X	Blind right			Good
Green 204	Orange S-38 128Y		Char X	RWF			Good
				Carmel WF			Good
				Carmel white strip			Good

<sup>a</sup> Aborted December 2, 1993

<sup>b</sup> Bled and analysed

<sup>c</sup> Bled but not analysed

Table 9 Field Evaluations of Ranch A Cattle on January 20, 1994 (Cont'd)

1993 Tag	Old Tag	ID No.	Breed	Type	Bled 93/12/06	Bled 94/01/20	Body Condition Score 94/01/20
Green 205			Simm	Tall			Good
Green 206			Black	Brockle face			Good
Green 207			Angus X				Med +
Green 208	Yellow 116		Char	White			Med +
Green 209	Blue W-34	911066	Red Angus	Red brockle			Good
Green 210	Blue 957		Char	WF			Good
Green 211	Blue U-103		Simm X				Good
Green 212	Green 174	911100	Black	BWF			Good
Green 213			Angus X				Good
Green 214	Orange U-48		Char				Good
Green 215	White 143		Saler				Good
Green 216	Orange U-54		Hereford	Blunt horns			Good, normal
Green 217	Yellow 203		Char X	Carmel WF			Med +
Green 218			Red Angus				Med +
Green 219	Green U-28		Pinzgaur X	Black			Good
Green 220			Black	"Star"			Good
Green 221	Green 158	911056	Black	BWF			Good
Green 222			Angus X				Good
Green 223			Bl Angus X	"Blueberry"			Med +
Green 224	Green U-130	911080	Shorthorn				Good, 39.4°C, springing, bagging up
Green 225			Simm X	WF			
Green 226			Limo	Red			
Green 227	Purple 17	911060	Hereford				
Green 228	White 18		Char X	Bald Face			Good
			Char X	3 yr, carmel			Good
			Here X	Red bald			Good
			Here X	face			Med +

<sup>a</sup> Aborted December 2, 1993

<sup>b</sup> Bled and analysed

<sup>c</sup> Bled but not analysed

Table 9

Field Evaluations of Ranch A Cattle on January 20, 1994 (Cont'd)

1993 Tag	Old Tag	ID No.	Breed	Type	Bled 93/12/06	Bled 94/01/20	Body Condition Score 94/01/20
Green 229			Holstein	BWF, two horns, "Lucy"			Med -
Green 230	Blue 9		Here X	BWF			Good, eyes normal
Green 231	Orange 29W		Here X	RWF			Good
Green 232	Z-62		Simm X	RWF GG			Good
Green 233	Orange 19 U			RWF			Med +
Green 234			Simm X	RWF			Good
Green 235	Orange 99		Char X	Carmel			Good
Green 236	Orange H36 H. Smith cow	911091	Angus X Shorthorn	Red			Med +, lice
Green 237	Black 9		Limo X	Carmel			Med +
Green 238	Blue 113	911076	Here X	RWF			Med -
Green 239	Orange 41 U H. Smith cow		Here X	RWF			Good
Green 240		940053	Angus X	BWF		b	Good, lice
Green 241			Here	RWF			Good, normal appearance
Green 242	Green 6		Char X	Carmel			Med -
Green 243			Simm X	Yellow White Face, bob tail			Good
Green 244	Orange 7 Green W 13	900570 940054	Simm X	Red & White, horns		c	Med -, normal
Green 245				BWF, black brockle face			Good, normal
Green 246				RWF, Brockle, red			Good
Green 247			Shorthorn	Carmel			Med -

<sup>a</sup> Aborted December 2, 1993

<sup>b</sup> Bled and analysed

<sup>c</sup> Bled but not analysed

Table 9 Field Evaluations of Ranch A Cattle on January 20, 1994 (Cont'd)

1993 Tag	Old Tag	ID No.	Breed	Type	Bled 93/12/06	Bled 94/01/20	Body Condition Score 94/01/20
Green 249	Blue U 102	911095					Med +, 39°C, ruminating, breathing okay
Green 250	Green A 23		Simm X	Yellow			Good
Black 1		930595		Light red	b	b	Good
Black 2		930601			b	b	Good
Black 3		940048	Here X	Brockle-face,		b	Med -
Black 4	Orange tag		Maine Anjou	R & W, bought 93/10/30			Good
Black 5			Hereford				
Black 6	Red 13		Hereford				Good
Black 7	Black 18		Char X				Good
Black 8			Simm	"Big bloody			Good
Black 9			Char X	Carmel			Med -
Black 10	Black 13		Char X	Carmel			Good
Black 11	Orange 46W		Pinzgaur				Good
Black 12			Hereford, small				Med +
Black 13	Red 17		Hereford				Med +
Black 14	Red 12		Simm X	Short ears			Good
Black 15	?White 130		Hereford	horns			Good
Black 16	Red 30		Shorthorn	Big speckled			Good
Black 17	Yellow 053		Simm	Red white			Good
Black 18	Black 1		Char X	Speckle face			Med +
Black 19			Hereford	Horns			Med +
Black 20	Red 11		Simm X	Light tan, bald face			Good
Black 21			Saler X	Red, white brockle			Good
Black 22	Yellow 30 H of A BC		Longhorn X Char	Carmel, longhorns			Med -

<sup>a</sup> Aborted December 2, 1993

<sup>b</sup> Bled and analysed

<sup>c</sup> Bled but not analysed

Table 9

Field Evaluations of Ranch A Cattle on January 20, 1994 (Cont'd)

1993 Tag	Old Tag	ID No.	Breed	Type	Bled 93/12/06	Bled 94/01/20	Body Condition Score 94/01/20
Black 23	Red Harty-100		Hereford				Med +
Black 24	White 7		Angus X	Red - white			Good
Black 25			Char - Black Angus				Good
Black 31	White 6		Angus X	Red - brockle			Med +
Black 36			Hereford	RWF			Good
Black 37			Char X	Carmel			Good
Black 38			Char X	Carmel,			Good
Black 39			Longhorn X	White with Red, bought 93/12/13			Med --
Black 40				Carmel WF, curly horn			
Black 41				Black			
Black 42			Longhorn X	White, black ears			Med -
Black 43			Simm X	RWF			
Black 44			Char X	Carmel			Good
Black 45	White 107		Simm				Med +
Black 46			Longhorn X	White, red			Med +
Black 47			Here X	Black, with white			Med -
Black 48			Here				Good
Black 49	Red 15		Here				Good
Black 50			Char X	Carmel			Good
Yellow				Carmel			
Yellow				BWF, fall 93			
Yellow 52				BBF, fall 93 calver			
Yellow 53				BWF, fall 93 calver			

<sup>a</sup> Aborted December 2, 1993

<sup>b</sup> Bled and analysed

<sup>c</sup> Bled but not analysed

Table 9 Field Evaluations of Ranch A Cattle on January 20, 1994 (Cont'd)

1993 Tag	Old Tag	ID No.	Breed	Type	Bled 93/12/06	Bled 94/01/20	Body Condition Score 94/01/20
Yellow 54				Brahman, fall 93			
Yellow 55				BWF, fall 93			
Yellow 56				calver			
Yellow 57			Longhorn X	BWF, fall 93			
Yellow 58				calver			
Yellow 59				White with red spots			Med +
Yellow 60				BWF, fall 93			
Yellow 61				BWF, fall 93			
Yellow 62				White, abscess on chin			
Yellow 63			Simm X	RWF, crop ears			
Yellow 64			Black Holstein	Black with white feet			Good
Yellow 65			Char X	Carmel brockle face			Good
Yellow 66	Black 3	930606	Longhorn X	White, red ears			Med -, ? April calving
Yellow				Carmel with			Med +
Yellow				Red blaze face			Med -
Yellow			Saler X				Med +
Yellow			Here X	RWF			Med +
Yellow			Simm	RWF			Med +
Yellow			Simm X	RWF			Med -, lice
103			Simm X	Yellow WF			Med -, lice
Yellow							
104							
Yellow			Here X	RWF			Med -
Yellow			Angus X	Red			Med +
Yellow			Simm X	Yellow WF			Good
Yellow				BWF, bob ears			
Yellow							
Yellow			Simm X	Light RWF			Good
Yellow			Here X	BWF			Good

<sup>a</sup> Aborted December 2, 1993

<sup>b</sup> Bled and analysed

<sup>c</sup> Bled but not analysed

Table 9

Field Evaluations of Ranch A Cattle on January 20, 1994 (Cont'd)

1993 Tag	Old Tag	ID No.	Breed	Type	Bled 93/12/06	Bled 94/01/20	Body Condition Score 94/01/20
Yellow 111			Here X Angus	Red blaze face			Med +
Yellow 112			Here X Holstein	BWF			Med +

<sup>a</sup> Aborted December 2, 1993

<sup>b</sup> Bled and analysed

<sup>c</sup> Bled but not analysed

cattle had discharge on their tails, were anorexic, or had nasal discharge, some blood tinged. Table 10 summarizes the clinical signs observed in the cows following the pipeline break, including nasal, ocular, and vaginal discharges, dyspnea and pneumonia, anorexia, diarrhea, depression, gaunt appearance, incoordination, and estrus-like behavior in pregnant cows. The ranch owner reported that about five days following the leak, one cow (G174) had vaginal discharge; the cow had a large, non-gravid flaccid uterus when rectally palpated on January 20 (Table 9). One yearling was scouring, infested with lice, and developed a rectal prolapse. The prolapse was repaired by the local veterinarian. Several cows in the herd had a lice infestation (Table 9). Two calves, born in December, appeared normal.

Using a body condition scoring technique, about 91% of the cows which were examined were a *medium +* or *good* (5 to 7 out of 9) and 9% were thinner with lower scores (Table 11).

The mean plasma Se concentration of cows bled January 20 was 273 ng/mL with a range of 78 to 542 (n=17), reflecting an average increase compared with the December mean concentration of Se (Table 6). The mean plasma Cu concentration was 689 ng/mL with a range of 465 to 1028 (n=17), reflecting a decrease compared with the December mean concentration of Cu. The mean serum vitamin E (alpha-tocopherol) concentration was 2.9 µg/mL, a value that probably reflects a treatment response to the vitamin E and selenium injections. The mean serum concentration of 2.9 µg/mL of alpha-tocopherol would be considered marginal status for adult cows (Puls, 1994).

A composite hay sample (ID No. 940043) was taken from timothy hay being fed to the cows (Table 7). Briefly, on a dry matter basis the protein concentration was 8.8%, the TDN estimate was 55.9%, the Cu concentration was 4.9 µg/g, the zinc concentration was 23.7 µg/g, the sulfur concentration was 0.13%, and the molybdenum concentration was 3.7 µg/g. The copper concentration is inadequate for beef cows, particularly with a molybdenum concentration of 3.7

Table 10 January Observations<sup>a</sup> of Clinical Signs in Cattle Following Pipeline Break

Nasal Discharge	Serous Ocular Discharge	Dyspnea/Pneumonia
G244	G24	G53
G241	G27	G63 (coughing)
G246	G62	G76
G82	G76	G235
No. 12 calf	G112	Carmel white face
G19 (bloody)	G162	Hereford calf
G98 (bloody)	G174	2 yearlings
G101 (bloody)	G199	2 bred replacement heifers
G164 (bloody)	G216	
Yearling	G230	
	G62 (ulcer)	
	G249 (cloudy eyes)	
	5 yearlings	
	3 bred replacement heifers	
	Calf No. 69	
Anorexia	Vaginal Discharge	Diarrhea
G66	G62	G94
G67	No. 74	Yearling calf
G83	G174	
G105	G201	
	G57 (bloody)	
Depression (mild-moderate)	Gaunt Appearance	Inco-ordination
G116	G11	G145
G230	G83	G62
G249		G95
	Estrus-like Activity ("Bulling") Numerous Cows	

<sup>a</sup> Cattle owner and veterinary observations

Table 11 Summary of Body Condition Scores of Ranch A Cows (January 1994)

		Medium--	Medium -	Medium +	Good	
BCS	1-2	3	3.5-4	5	6-7	8-9
No. cows		1	26	71	204	
% of cows		0.3%	8.6%	23%	68%	

$\mu\text{g/g}$  (NRC, 1996). The Ranch A owner continued to supplement the cows *ad libitum* with trace mineral (Table 8) mixed with loose salt.

*Field Investigation of Ranch B.* The field team of C. Campbell and M. Mostrom proceeded to Ranch B on January 20 to observe the cows and calves and yearlings. The consulting veterinarian for the petroleum company was at Ranch B evaluating animals and nutrition following the pipeline leak. The cows and yearlings were located adjacent to the ranch house, southwest of the pipeline leak. The field team walked through the approximately 160 cows and 90 yearlings. The cows visually appeared in good body condition with adequate fat stores.

Problems noted in the herd included a reddened appearance of the vagina in a bred heifer (No. 74). The animal was treated with antibiotic; the heifer delivered a live calf on January 25. A three day-old heifer calf (No. 66) was examined; the calf was weak, with bilateral, increased respiratory sounds. The calf was treated with antibiotics. A week-old heifer calf (No. 69) had serous discharge from the nostrils. Additionally, a Simmental-cross yearling heifer had marked intermandibular edema; the animal was eating. The ranch owner mentioned that the heifer had tried to jump a fence in mid-December and the clinical signs appeared soon after.

Approximately 60 steers and 30 heifers, almost a year-of-age, were examined while eating hay at a bale feeder. Hay was available *ad libitum* at the feeder. The yearlings were slightly gaunt in appearance and had rough hair coats; they appeared to have lost weight as compared with their appearance in early December. A composite sample (ID No. 940042) was taken from the alfalfa/timothy hay being fed to the yearlings (Table 7). A composite hay sample (ID No. 940041) was also taken from timothy/alfalfa hay fed to the cows and bulls. Briefly, the protein content was 8.2% and 6.7%, the TDN estimate was 50.6% and 50.4%, the copper concentration was 4.3  $\mu\text{g/g}$  and 3.8  $\mu\text{g/g}$ , the sulfur content was 0.09% and 0.08%, the zinc concentration was 21  $\mu\text{g/g}$  and 15  $\mu\text{g/g}$ , and the molybdenum was 1.2  $\mu\text{g/g}$  and <1.0  $\mu\text{g/g}$  in samples No. 940042 and No. 940041, respectively, on a dry-matter basis. The cows and yearlings were also being fed silage from the home place; the owner had started feeding silage in December.

The cattle were supplemented, free choice, with trace minerals in the form of Weatherguard No. 2 with Se (Table 8) and vitamins A, D, and E mixed with salt. The cows and yearlings had *ad libitum* access to a molasses-protein supplement with selenium (Table 12) provided in two licks. These supplementations were initiated in early December.

By January 20, seven calves had been born. On January 21, cow No. 165 (ID No. 940040) delivered two non-viable bull calves with the placenta. The cow was bled by the field team for trace nutrient status; the plasma Se was 69 ng/mL and the plasma Cu was 722 ng/mL. The bull calves were necropsied on January 22. The gross necropsy descriptions are provided in Appendix B. Briefly, one calf (ID No. 940038) weighed 30 kg, had a normal component of body fat, and dark red, glistening lungs. The lungs floated indicating some inflation of alveoli. The viral isolation and FA tests against IBR and BVD viruses were negative. A trace mineral determination of fetal tissue provided a liver Se concentration of 1.2 µg/g, reflecting an inadequate Se status (Puls, 1990), and a liver Cu concentration of 539 µg/g, reflecting an adequate Cu status (Puls, 1990). The liver lead concentration of 1.3 µg/g and kidney lead concentration of 0.7 µg/g are normal background concentrations (Osweiler *et al.*, 1985).

The histopathology revealed multifocal hepatocellular hydropic degeneration that was considered significant in a newborn calf (Stair and Kosanke, 1997). The histopathological diagnosis for calf No. 940038 follows:

- (1) Adrenal cortical hypoplasia
- (2) Pulmonary capillary leakage and atelectasis
- (3) Acute bronchopneumonia
- (4) Lymphadenitis with follicular necrosis
- (5) Minimal parathyroiditis
- (6) Hepatocellular degenerative changes
- (7) Spinal cord, status spongiosa.

The gross necropsy of the second bull calf (ID No. 940039) revealed similar findings. The calf weighed 29 kg, had a normal component of fat, and had dark red, glistening lungs. The calf also had prominent bilateral enlargement of thyroid glands. The viral isolation and FA tests against IBR and BVD virus were negative, and the diagnostic immunohistochemistry tests against Bovine Herpes Virus Type 1 and BVD virus in tissue section were negative. The liver Se

Table 12 Protein Supplement Provided to Cows on Ranch B

Nutrena® Controlled Release Liquid Supplement-32	
Crude Protein, Min.	32.0%
Sodium, Act.	1.20%
Calcium, Act.	0.10%
Phosphorus, Act.	75%
Magnesium, Act.	1.0%
Potassium, Act.	3.0%
Zinc, Act.	600 mg/kg
Iodine, Act.	10 mg/kg
Copper, Act.	150 mg/kg
Cobalt, Act.	10 mg/kg
Iron, Act.	300 mg/kg
Manganese, Act.	300 mg/kg
Vitamin A, Min.	90,000 IU/kg
Vitamin D <sub>3</sub> , Min.	20,000 IU/kg
Vitamin E, Min.	20 IU/kg

This feed contains added selenium at 4 mg/kg. This includes not more than 20% equivalent crude protein from non-protein nitrogen. The ingredients used in this feed are: Beet Molasses, Cane Molasses, Urea, Salt, Phosphoric Acid, Ammonium Polyphosphate, Vitamin A, Vitamin D<sub>3</sub>, Vitamin E, Ethylene Diamine Dihydrolodide (source of Iodine), Zinc Sulfate, Manganese Sulfate, Copper Sulfate, Iron Sulfate, Sodium Selenite, Mineral Oil. Provided by Cargill Limited, Winnipeg, Manitoba.

concentration of 1.7 µg/g reflects a borderline adequate status (Puls, 1990), and the liver Cu concentration of 247 µg/g reflects an adequate status. The liver lead of 1.2 µg/g and kidney lead concentration of 0.8 µg/g are normal background concentrations (Osweiler *et al.*, 1985).

The histopathology revealed intrauterine immunostimulation and severe acute stress with adrenocortical congestion and hemorrhage (Stair and Kosanke, 1997). The histopathological diagnosis on calf No. 940039 follows:

- (1) Acute hepatocellular degenerative change
- (2) Pulmonary atelectasis and capillary leakage
- (3) Lymphoid immunostimulation

- (4) Multifocal neutrophilic lymphadenitis
- (5) Adrenocortical sinusoidal congestion and adrenocortical hemorrhage
- (6) Optic nerve, perineural edema.

*February 8-10.* A field investigation was made to Ranches A and B by M. Mostrom and C. Campbell. *Ranch A.* The Ranch A owner reported that it was difficult to determine when cows were going to calve; the cows did not display relaxation in the pelvic and vulvar region nor did the cows show distention of the udder prior to calving ("bag up"). Because of the lack of clinical signs of the initiation of parturition, the owner was walking his cow herd every hour and one-half with the cold weather. To date, the owner had calved out 32 live calves with three sets of twins. We observed an abnormal cow (ear tag G83) who continued to be gaunt in appearance, anoretic, and walk with an abnormal gait ("goose-step").

On February 9, a Simmental cow (ear tag G12) had a dystocia. A breach heifer was delivered with assistance and a bull calf pulled later. The bull calf died a few hours later. A Charolais cow (ear tag G147) delivered a 39 kg (86 lb) heifer calf (ear tag Gr D14) that we observed as incoordinated, showing difficulty walking and sucking.

*February 9. Field investigation of Ranch B.* We examined several sick calves at Ranch B. One female calf (ear tag No. 19 or ID No. 940119) was born on February 4 slightly weak and hypothermic. The ranch owners reported that they took her temperature, initially 34°C, brought the calf into the house and gave her colostrum. The calf's temperature gradually returned to 37°C, and the calf was treated with antibiotics. Our examination of the calf revealed a temperature of 39.6°C, bilateral raspy respiration, and poor vision (the calf walked into some objects and appeared to have a poor menace response). Blood samples were taken for clinical pathological parameters and analyzed (Appendix A). Briefly the hematology analyses revealed a white blood count (WBC) of  $10.7 \times 10^9/L$ , an elevated count of relative and absolute band lymphocytes that consisted of blast cells, metamyelocytes, myelocytes, and some degenerative white blood cells (indicating a demand and recent release of lymphocytes) and a low relative and absolute lymphocyte count. The serum chemistry data revealed low creatinine, total protein, albumin, and iron (Fe) concentrations, and high phosphorus (P), potassium (K) concentrations and elevated albumin/globulin ratio. The following enzymes were elevated: aspartate aminotransferase (AST), alanine aminotransferase (ALT), gamma glutamyltransferase (GGT), amylase, and creatinine phosphokinase (CPK) that was 2210 IU/L.

A 45 kg bull calf (ear tag No. 123 or ID No. 940123) was born in the barn at about 01:30 and did not appear to the owner to have control of skeletal muscles, displayed a stretched neck and back, and was hypothermic (couldn't record a temperature). The owner took the calf to the house, it started to shiver at 06:45, and at 07:30 the temperature as 35.9°C. The clinical pathology on blood samples (Appendix D) revealed a low red blood count ( $4 \times 10^{12}/L$ ), hemoglobin, and hematocrit. The WBC was elevated,  $12.7 \times 10^9/L$ , and the relative and absolute neutrophil, band lymphocyte, and monocyte counts were also elevated. The relative and absolute lymphocyte counts were low. The serum chemistry data revealed low glucose, total protein, albumin and blood urea nitrogen (BUN) concentrations, and elevated levels of calcium (Ca), K, total and direct bilirubin, alkaline phosphate, lactate dehydrogenase (LDH), CPK at 21640 IU/L, AST, and ALT. The highly elevated CPK was likely reflecting muscle damage and is supported by the clinical signs.

Another bull calf (ear tag 79 or ID No. 940120) was born outside where the temperature was about -14°C (Appendix E). At 4:45, the rancher took the calf into the house where the rancher gave the calf colostrum and recorded the temperature of the calf, 32.8°C. By 11:00, the calf's temperature was 38.4°C. Because the calf's dam did not have enough milk, the calf was put on cow No. 189 who had calved twins on February 2 that died. Blood samples were taken from calf No. 940120 (Appendix D). Briefly, the hematology exam revealed a WBC of  $10.2 \times 10^9/L$  which is within a normal range. The serum chemistry evaluation revealed low creatinine, total protein, albumin, and Fe concentrations. The Ca, K, and P concentrations were elevated.

Blood samples were taken from an apparently normal twin calf (ear tag No. 98 or ID No. 940122) (Appendix D). The twin calves, a 31 kg bull calf and a 27 kg heifer calf were born at 8:45 on February 2. The hematocrit and hemoglobin concentrations, and red blood count (RBC) were depressed in the hematology analyses. In the blood chemistry analyses, creatinine, total protein, albumin, magnesium (Mg), chloride (Cl), and Fe concentrations were low. Calcium and P concentrations were elevated. The activities of GGT and amylase were elevated.

Blood samples were taken from another live twin calf (ear tag No. 144 or ID No. 940124). The twins were born on January 30; the ranch owner reported that the heifer calf developed a diarrhea and pneumonia, was treated with antibiotics, and died at seven days of age. The hematology tests revealed low hemoglobin, hematocrit, and RBC ( $4.33 \times 10^{12}/L$ ) values (Appendix D). Creatinine, total protein, albumin, Mg, sodium (Na), and Fe concentrations were depressed. The albumin/globulin ratio was elevated, as was the K concentration and amylase activity.

Blood samples were taken from a 30 kg heifer calf (ear tag No. 83 or ID No. 940121) born on February 7 to a two year-old heifer. The blood analyses are provided in Appendix D. The hemoglobin concentration was depressed, 84 g/L, as compared with the normal values. The relative neutrophil count and relative and absolute band counts were elevated. The serum was slightly icteric and had elevated concentrations of total (29 µmol/L) and direct (8 µmol/L) bilirubin and K, and low concentrations of total protein and albumin. The GGT concentration was increased and probably reflects colostrum intake. The serum from several calves was analyzed for T3 (triiodothyronine) and T4 (thyroxine) because of post-mortem observations of enlarged thyroid glands and observed clinical signs (hypothermia). The results are listed in Table 13.

Several cows were bled for serum analysis to determine the progesterone (P4) and estrogen (E2 or estradiol) concentrations (Table 14). The ranch owners had observed abnormal maternal behavior in their cows which were kept in the herd because they were good mothers. In sheep, a ruminant species, maternal behavior is dependent on several factors: estrogens, mechanical stimulation of the genital tract, and olfaction (Poindron and Levy, 1990). Additional factors in maternal behavior that should be considered are: progesterone concentrations; prolactin or prolactin-like hormones; oxytocin, noradrenaline, and endogenous opiates acting centrally (Bridges, 1990; Insel, 1990). Some of the cows were exhibiting abnormal maternal behavior: cow No. 184 (ID No. 940132) would not take her calf and cow No. 154 (ID No. 940130) whose calf was born and died on February 7, wanted to mother every calf. Blood samples were also taken from the dam (ID No. 940127) of calf No. 19 (ID No. 940119); we observed evidence of poor vision in that the calf repetitively had to be put on the teat to suck and was then fairly aggressive in nursing. Blood was taken from the dam (ear tag 123 or ID No. 940128) of the incoordinated calf (ID No. 940123) and from cow No. 180 (ID No. 940131) who lost her calf on February 7. Serum from several Ranch A cows, pregnant cows (ID No. 900397, No. 900569, and No. 940049) and cows that were reported to have aborted (ID No. 930599 and No. 940051) were included for P4 and E2 analyses. Trace nutrient analyses were performed on peripheral blood samples and are included in Appendix E.

Table 13 Serum T3 and T4 Concentrations in Ranch B Calves

ID No.	Sex	Description Ranch B	Born	Bled	T3 <sup>a</sup> (nmol/L)	T4 <sup>a</sup> (nmol/L)
940119 <sup>b</sup>	F	Sick calf	94.02.04	94.02.09	2.00	69
940122	M	Normal calf	94.02.02	94.02.09	2.15	83
940123 <sup>c</sup>	M	Sick calf	94.02.09	94.02.09	5.28	276
940124 <sup>d</sup>	M	Normal surviving calf	94.01.30	94.02.09	3.33	95
940238 <sup>e</sup>	F	Sick calf	94.02.25	94.03.17	0.89	14

<sup>a</sup> Ratioimmunoassay (RIA) Analysis for T3 – triiodothyronine and T4 – thyroxine by the Western College of Veterinary Medicine, Endocrine Service Lab, Saskatoon, SK

<sup>b</sup> Poor vision, dyspnea, hypothermia, weak

<sup>c</sup> Hypothermia, opisthotonus, uncontrolled function

<sup>d</sup> Surviving twin calf

<sup>e</sup> Born in a shed (-35°C); later developed bilateral sloughing of hind feet

The owner of Ranch B was feeding silage to cows and yearlings. We took a composite sample for Se determination. The moisture concentration was 64% and Se concentration was 0.09 mg/kg (ppm).

February 11. The petroleum company sponsored a noon meeting for local area residents, local livestock producers, consultants to the petroleum company, Alberta Agriculture representatives, and AEC representatives (M. Mostrom and C. Campbell). At the meeting, the petroleum company presented information and data on the incident, detection of the leak and initial response and clean-up procedures, and proposed evaluation of livestock (Mostrom, 1994c). The local residents provided comments on the presentations.

The owner of Ranch A informed the authors that several of his cows were not coming into milk and that he had noted calves did not want to suck and appeared not to have "feeling" of the tongue. He also reported that some cows displayed abnormal gaits, some walked in a "pace" pattern, a few cows staggered, and one cow came into the yard with a pronounced head tilt - holding her head 20 degrees off centre.

Table 14      Serum Progesterone (P4) and Estradiol (E2) concentrations in Cows on Ranches A and B

ID No.	Description	Calved	Bled	Serum P4 <sup>a</sup> ng/mL	Serum E2 <sup>a</sup> pg/mL
900397	Pregnant cow (G12)	94.02.09	94.01.20	7.9	22.5
900569	Pregnant cow (G11)	94.02.18	94.01.20	3.8	33.4
940049	Pregnant cow (G83)	94.02.14	94.01.20	3.0	20.1
930599	Aborted 1 month prior (R2)		94.01.20	0.6	1.3
940051	Aborted 7 days prior (Gr 174)		94.01.20	0.8	2.0
940127	Post partum (dam to 940119)	94.02.04	94.02.11	0.1	9.4
940128	Post partum (calf incoordinated)	94.02.09	94.02.11	0.1	8.7
940131	Post partum (lost calf)	94.02.07	94.02.11	0.1	4.4
940130	Abnormal behavior <sup>b</sup>	94.02.07	94.02.11	0.1	7.3
940132	Abnormal behavior <sup>c</sup>	94.02.09	94.02.11	0.1	7.3

<sup>a</sup> Analysis for P4 – progesterone and E – estradiol by Western College of Veterinary Medicine Endocrine Service Lab, Saskatoon, SK

<sup>b</sup> Wanted to mother any calf

<sup>c</sup> Poor maternal behavior – would not mother calf

*February 14. Ranch A.* A Charolais heifer calf (ear tag D-14) and born to cow No. G147, was brought to AEC for a necropsy. The calf was born February 9 and died on February 13. The owner reported that the calf staggered while walking ("pace-like" gait) appeared very loose-jointed on the back legs and pointed her nose out like a hunting dog. A video was taken by the owner of the calf.

According to the rancher, after the cow calved, she had a lot of milk and fed the calf. Later, the calf acted "stupid" and would not suck. Therefore, the owner milked the cow out and fed (stomach tubed) the calf. The calf became recumbent on February 12, the calf was put in a heated area, and died in the morning of February 13. The owner said that the cow "dried up" right after the calf died and did not appear to miss the calf or call for her calf, an abnormal behavior.

The gross necropsy of the calf (ID No. 940134) is listed in Appendix B. Briefly, the calf weighed 41 kg, had hemorrhages on the posterior aspect of the tongue, froth in the trachea, and a wet appearance to the lungs. The viral isolation and FA tests against IBR and BVD virus were negative. Tissue samples cultured for bacteriology indicated a non-hemolytic *streptococcus* growth on Edwards media and a heavy contamination of coliform bacteria on EMB plates. The liver Se, 5.7 µg/g, and liver Cu, 948 µg/g, concentrations were high (Puls, 1990).

The primary lesions in histopathology were adrenal cortical hemorrhage and microthrombosis, aortic hemorrhage, and pulmonary microthrombosis that could be related to DIC (Stair and Kosanke, 1997). The histopathologic diagnosis for calf No. 940134 included:

- (1) Generalized intravascular bacterial aggregates
- (2) Aortic hemorrhage
- (3) Cytoplasmic neuronal vacuolation involving the Gasserian ganglion
- (4) Aspiration of gastrointestinal contents
- (5) Pulmonary microthrombosis
- (6) Adrenal hemorrhage and microthrombosis
- (7) Lymphoid hypoplasia.

These lesions are not associated with the lesions observed in copper poisoning. Copper poisoning in calves typically is associated with acute intravascular hemolysis, acute periacinar necrosis, and possibly chronic liver damage and diffuse fibrosis (Jubb *et al.*, 1985).

*February 15. Field investigation of Ranch A.* The field team, consisting of M. Mostrom and C. Campbell, made clinical observations on several animals in the herd that will be described.

A Charolais-cross cow (ear tag No. G83) was gaunt and had been exhibiting estrus-like behavior ("bulling cows"). She calved on February 14 and had a 50 kg bull calf (ear tag No. Y46); she did not come into milk or letdown milk for about 12 hours post-calving.

A cow (ear tag No. G12) calved on February 9 and had twins. One cow (ear tag No. G203) calved a heifer calf on February 13 that was exhibiting an abnormal gait - a "pace-like" gait. Cow (ear tag No. G81) calved a heifer on February 12, the 40 kg calf had a posterior presentation at birth. The calf (ear tag D-20) was observed shaking its' head (tremors) and exhibiting an abnormal gait, a wide bow-legged stance as if trying to balance on the rear legs. The calf was examined and videos taken. A 36 kg female Hereford calf was born on February 11 to a cow (ear tag No. G34) and exhibited an abnormal right rear leg and abnormal gait. Another heifer calf, born at 39 kg on

February 11 to cow No. G118, had slight edema in the maxillary area. To date, the ranch owner had 81 live calves and four sets of twins.

Cow (ear tag No. G93) - a carmel white face cow, was incoordinated, dazed and appeared to have glazed eyes. [The cow would calve on February 28, delivering a live heifer calf that she stepped on and killed.] Cow (ear tag black No. 37) appeared hesitant to step and staggered a little. [The cow would calve a live heifer calf on February 28]. Another cow (ear tag No. G19) had an abnormal gait in that her right hind leg appeared to "give-way" a bit when she walked. [The cow would calve on February 20, the calf's front feet were crossed and the rancher had an easy calf pull of a 41 kg bull calf. The calf (ear tag No. Y76) died on April 19].

*Ranch B.* The field team examined several calves at Ranch B, and transported two calves to AEC for necropsy. One Red Angus calf was born dead to cow No. W1 on February 14 at 21:00, the calf had one leg back at presentation. The calf was necropsied on February 16 (Appendix B). The female calf weighed 37 kg, was autolytic, with a normal component of body fat. The lungs were a solid red color and did not float in water. The viral isolation and FA tests against IBR and BVD viruses were negative. The liver Se, 2.8 µg/g, and liver Cu, 294 µg/g, concentrations are considered adequate (Puls, 1990).

The histopathologic evaluation listed the autolytic changes as present in most of the tissues, but not severe enough to obscure any lesions (Stair and Kosanke, 1997). There was evidence of lymphoid immunostimulation in the thymus and spleen, and a section of spinal cord had a focal neutrophilic-lymphocytic meningitis. The lesions were not of sufficient extent or severity to provide a meaningful diagnosis.

Another heifer calf was examined on the farm. This calf was born twin to a bull calf on February 2 from cow (ear tag No. 98) (one of the twin calves was examined on February 10). The calf initially was hypothermic (35.7°C) and later developed a diarrhea which was treated with antibiotics and fluids. The calf (ID No. 940136) was comatose upon examination and blood was taken for clinical pathology (Appendix D). Briefly, the hematology revealed a low RBC of  $3.6 \times 10^{12}/L$ , low hemoglobin and hematocrit concentrations. The WBC was  $12.1 \times 10^9/L$  with elevated relative and absolute neutrophil counts. The serum chemistry panel showed that the calf had low total protein, albumin, and creatinine concentrations. The serum BUN, P, Na, K, and Cl concentrations were elevated. The activities of CPK and amylase were elevated.

The calf (ID No. 940136) was exsanguinated on February 16 and necropsied (Appendix B). Briefly, the calf weighed 36 kg, had prominent enlargement of the thyroid gland, a red color in the

lung tissue and consolidation of the ventral, right lung lobes, a milk curd in the stomach, and evidence of a diarrhea in the perianal area. The viral isolation and FA tests against IBR and BVD viruses were negative. The diagnostic immunohistochemistry tests against bovine coronavirus and rotavirus were negative in sections of small and large intestines. The liver Se concentration was 8.6 µg/g, a very high value (Puls, 1990). The liver Cu concentration was 524 µg/g which is considered a high, adequate value (Puls, 1990).

The histopathology diagnosis on calf No. 940136 included an enterocolitis, ruminoreticulitis, and bronchopneumonia with secondary lymphadenitis and nephritis; the calf suffered from a severe gastrointestinal infection with a secondary pneumonia and nephritis (Stair and Kosanke, 1997). The large intestinal lesions are consistent with a coronaviral infection, although evidence of the virus could not be demonstrated by the diagnostic immunohistochemistry. The histopathology diagnoses of calf No. 940136 follows:

- (1) Enterocolitis, moderate-to marked, subacute-to-chronic
- (2) Reticulitis-rumenitis, marked neutrophilic (mycotic)
- (3) Bronchopneumonia, moderate, acute
- (4) Non-suppurative interstitial nephritis
- (5) Septic splenitis
- (6) Lymphoid hypoplasia

The lesions are not consistent with copper poisoning and cannot be completely associated with selenium toxicosis (Kelly, 1985; Yager and Scott, 1985); the gastrointestinal lesions in calf No. 940136 were associated with a bacterial etiology, and no myocardial degeneration or nephrosis which are consistent with Se poisoning were reported.

*February 21. Ranch A.* The field investigation team consisted of M. Mostrom and C. Campbell. The cattle, cows and calves were in the corrals and were walked through and observed clinically. Only one calf was born with a gait problem in the last week. A cow prolapsed a uterus following calving on February 16, and the ranch owner put the uterus back in and sewed up the cow. The owner reported that the cow became very aggressive, charged people, took a fence, and died.

*Ranch B.* The field investigation team walked through the Ranch B cattle herd. The team observed several cows in estrus-like behavior, jumping other cows. The heifer yearlings were slightly gaunt and did not appear to have a good appetite in their consumption of a hay bale. The

Ranch B owners reported that they had smelled chemical odors most of the previous night. The steer calves had been sold several days prior to this field trip.

Two calves died (with a total of 11 dead calves to date) and were taken to AEC for necropsy. A male, twin calf (ID No. 940137) that had been bled on February 15, had been successfully placed on another cow to nurse. The calf died on February 21 and was necropsied on February 22 (Appendix B). Briefly, the calf weighed 31 kg, had little body fat, and had scattered, small hemorrhages throughout all of the lung lobes. The viral isolation and FA tests against IBR and BVD virus were negative. The diagnostic immunohistochemistry tests in small and large intestine paraffin sections against bovine coronavirus were positive and against rotavirus were negative. The liver Se concentration of 16 µg/g would be considered high to toxic (Puls, 1990). The liver Cu concentration of 502 µg/g would be considered adequate (Puls, 1990).

The histopathologic examination noted a severe enterocolitis, that would be consistent with lesions from a coronavirus infection, bronchopneumonia, and lymphadenitis (Stair and Kosanke, 1990). A hemorrhagic adrenalitis was thought to be a sequela to the diarrhea. Also noted as unique was the hypoplasia of bone marrow. The lesions are not associated with those of Se poisoning (Yager and Scott, 1985). The histopathologic diagnosis of calf No. 940137 follows:

- (1) Enterotyphlocolitis, marked
- (2) Hemorrhagic adrenalitis
- (3) Lymphadenopathy; lymphadenitis with sinus histiocytosis
- (4) Lymphoid hypoplasia
- (5) Bronchopneumonia, acute, neutrophilic
- (6) Neuronal cytoplasmic vacuolation involving the Gasserian ganglion.

The second calf that died on February 21 was the calf born to cow No. 19 or calf ID No. 930119. The history and gross necropsy on the calf are given in Appendix B. Briefly, the 17 day-old, female calf had been weak, hypothermic and had exhibited visual difficulty. The calf weighed 28 kg and had little body fat. The right rear, lower leg was reddened and the right, draining lymph nodes were enlarged. The viral isolation and FA tests against IBR and BVD were negative. The liver Se, 4.9 µg/g, and liver Cu, 280 µg/g, concentrations were adequate and marginally adequate, respectively (Puls, 1990).

The histopathologic findings included lymphoid hypoplasia, axonal swelling with leukomalacia of the brain stem, and cytoplasmic neuronal vacuolation involving the Gasserian

ganglion (Stair and Kosanke, 1997). The neurologic observations may explain the clinical symptoms of poor vision and mobility. The histopathologic diagnosis for calf No. 940119 follows:

- (1) Aspiration of gastrointestinal contents
- (2) Lymphoid hypoplasia
- (3) Axonal swelling with leukomalacia of the brain stem
- (4) Cytoplasmic neuronal vacuolation involving the Gasserian ganglion.

February 27. Three Ranch A calves were brought to AEC for necropsy by M. Mostrom, C. Campbell, and S. Herbut. The gross necropsy findings are listed in Appendix B.

A Simmental/Hereford cross, male calf was born to cow (ear tag No. 202) on February 23 and died in the morning of February 27. The history on the calf included that the ranch owner had stomach tubed the calf with warm fluids and milk, treated the calf with antibiotics, and kept the calf in the barn trying to sustain a normal body temperature. The ranch owner reported that the nose and ears seemed to freeze on the calf for no reason.

The calf weighed 55 kg and had diffuse hemorrhages in the fascia and subcutaneous tissue of the neck, thorax, and abdomen. The lungs were diffusely red and consolidated. The heart had both epicardial and endocardial hemorrhages, the kidneys were dark red, pulpy, and friable, and a thoracic area of the spinal cord was hemorrhagic. Viral isolations and FA tests against IBR and BVD virus were negative. Diagnostic immunohistochemistry tests in tissue sections against bovine coronavirus, rotavirus and BVD virus were negative, as was a test of spleen section against *Salmonella*.

Tissue sections were submitted for bacteriology culture. No campylobacter or *Salmonella* were cultured. The EMB (eosin methylene blue) plates showed a growth of coliforms, and the Edwards plates of kidney, lung, liver, spleen, and lymph node sections had a heavy growth of streptococcus, identified as *Enterococci faecalis*. The liver Se, 2 µg/g, and liver Cu, 344 µg/g, concentrations would be considered adequate (Puls, 1990).

The histopathologic findings were consistent with a diagnosis of septicemia and coagulopathy (Stair and Kosanke, 1997). The lymphoid hypoplasia and hypoplastic thyroid were thought to be related to immunosuppression or decreased resistance to infection by an opportunistic pathogen (that is ordinarily considered a nonpathogen). The histopathologic diagnosis of calf No. 940153 follows:

- (1) Multiple large hemorrhages in connective (mesenchymal) tissue
- (2) Acute hemorrhagic and neutrophilic bronchopneumonia with atelectasis

- (3) Neutrophilic thymusitis with epithelial necrosis at centers of the thymic lobules
- (4) Purulent lymphadenitis in multiple nodes. Lymphoid hypoplasia
- (5) Hypoplastic thyroid
- (6) Renal/perirenal hemorrhage
- (7) Hemorrhagic orchitis
- (8) Cytoplasmic vaculation involving the Gasserian ganglion
- (9) Hemorrhagic optic perineuritis.

A Charolais/Angus cross, female calf was born to cow (ear tag No. G186) on February 22. The calf appeared normal in the early morning of February 26, but was recumbent with an unrecordable body temperature within two hours. The ranch owner gave the calf fluids via a stomach tube and placed the calf in a heated box, but the calf died shortly thereafter. The calf (ID No. 940154) weighed 37 kg, and had hemorrhages and froth in the nasal passages, froth in the trachea, and had red, consolidated tissue in 45% of the right lung lobes. Epicardial and endocardial redness/hemorrhages were noted. A milk curd was observed in the stomach. Viral isolation and FA tests against IBR and BVD viruses were negative. Tissue submitted for bacteriology had streptococcal colony growth from the lung, liver, lymph node, and spleen. The streptococci were identified as *Enterococci faecalis*. The liver Se concentration of 7 µg/g would be considered a high-toxic value (Puls, 1990). The liver Cu concentration of 570 µg/g would be considered a high adequate value (Puls, 1990).

The histopathologic findings of the calf included lymphoid hypoplasia, fibrinopurulent meningitis, fibrinopurulent encephalitis, and intravascular bacterial aggregated into the brain (Stair and Kosanke, 1997). The lesions are not similar to those associated with Se poisoning (Yager and Scott, 1985b). The histopathologic diagnosis of calf No. 940154 follows:

- (1) Heart valvular cusp hemorrhage with fibrin deposition and valvular endocarditis
- (2) Lymphoid hypoplasia
- (3) Subacute fibrinopurulent meningitis
- (4) Subacute fibrinopurulent Gassarian ganglioneuritis
- (5) Cytoplasmic vacuolation on the Gassarian ganglion
- (6) Subacute fibrinopurulent encephalitis
- (7) Intravascular bacterial aggregates primarily involving the brain
- (8) Subacute fibrinopurulent optic perineuritis.

A Saler/Charolais cross, female calf was born to cow (ear tag No. 131) on February 16. The ranch owner reported that the calf appeared normal at 05:00 on February 24, and dead at 06:30. The calf (ID No. 940155) was frozen and had been dead for 72 hours prior to the necropsy (Appendix B). The calf weighed 34 kg and had redness/hemorrhage on the right ventricle epicardium. Virus isolation and FA tests against IBR and BVD viruses were negative. The liver Se, 2.7 µg/g, and liver Cu, 710 µg/g, would be considered high adequate values (Puls, 1990).

The histopathologic findings included lymphoid hypoplasia and adrenal cortical congestion and hemorrhage, an acute stress reaction that could be related to toxemia or trauma [a special stain did not reveal microthrombosis] (Stair and Kosanke, 1997). A few organs had mild autolysis and freeze artefacts. The histopathologic diagnosis of calf No. 940155 follows:

- (1) Pulmonary capillary leakage characterized by edema
- (2) Lymphoid hypoplasia
- (3) Adrenal cortical congestion with hemorrhage
- (4) Cytoplasmic vacuolation involving the Gasserian ganglion.

The ranch owner said that on February 26 he had lost two more calves with similar clinical signs. Some of these observed problems in the cattle coincide *in time* with the reports by local residents of obnoxious odors and the shutdown of the clean-up operations for a day.

*March 8.* The owners of Ranch A brought two calves to AEC for necropsy (Appendix B). A Charolais male calf was born on February 16 to cow No. G213. The owner did not notice any clinical signs, but found the calf dead in the pasture on March 7 with a portion of the intestine pulled out from the navel. The calf weighed 72 kg and had good body fat. The lungs had a diffuse, bilateral redness, particularly the caudo-dorsal lobes, appeared wet, and had froth in the trachea and bronchi. The kidney had small (1 to 1.5 cm) round areas of greenish discoloration, the liver had scattered pale appearing areas, and the heart had a darker red appearance on the left ventricle epicardium. Tissue sections of liver, lung, and spleen were tested against *Salmonella* by diagnostic immunohistochemistry and found to be negative. Tissues submitted for bacteriology culture had a heavy growth of coliforms, that was probably post-mortem invasion. The liver Se concentration, 0.8 µg/g, would be considered marginal (Puls, 1990). The liver Cu concentration, 125 µg/g, would be considered adequate (Puls, 1990).

The histopathology findings were of a multifocal necrotizing hepatitis with "paratyphoid nodule" formation, interstitial nephritis, necrotizing splenitis, and a multifocal non-suppurative encephalitis and meningitis (Stair and Kosanke, 1997). The pathologists stated that *the lesions were*

consistent with septicemia, possibly due to *Salmonella*. However, no *Salmonella* was demonstrated by diagnostic immunohistochemistry technique, nor were clinical signs of salmonellosis observed in the herd. The authors do not consider *Salmonella* to be an infectious disease problem in the herd. The histologic diagnosis of calf No. 940158 follows:

- (1) Multifocal necrotizing hepatitis with "paratyphoid nodule" formation
- (2) Multifocal non-suppurative interstitial nephritis
- (3) Severe capillary leakage characterized by hemorrhage, edema and hyaline membrane formation
- (4) Diffuse necrotizing splenitis
- (5) Multifocal non-suppurative encephalitis and meningitis
- (6) Cytoplasmic vacuolation involving the Gasserian ganglion

A four day-old Charolais, male calf (ID No. 940159) was born to cow No. G144, and died on March 8. The ranch owner reported that he observed no clinical signs in the calf. The calf was weighed, 45 kg, and necropsied (Appendix B). The lungs were diffusely red and wet. The heart had scattered redness/hemorrhage on the epicardium, on the tricuspid valve, and left atrium endocardium. The calf had a milk curd in the stomach. Lung, lymph node, and kidney tissue samples submitted for bacteriology culture had a growth of alpha-hemolytic *streptococcus*, the tissues also had a heavy growth of coliforms. The liver Se, 2.1 µg/g, and liver Cu, 541 µg/g, concentrations would be considered adequate (Puls, 1990).

The histopathology lesions in the liver, gall bladder, kidneys, and adrenals were consistent with DIC and septic shock (Stair and Kosanke, 1997). The histopathology diagnosis for calf No. 940159 follows:

- (1) Disseminated intravascular coagulation involving primarily the liver, gall bladder, kidneys, and adrenals
- (2) Intravascular bacterial aggregates
- (3) Aspiration of gastrointestinal contents
- (4) Renal, adrenal and heart valve cusp hemorrhage
- (5) Acute lymphadenitis with lymphoid hypoplasia
- (6) Valvular endocarditis.

March 16. Ranch A. A field investigation to Ranch A was made by M. Mostrom and C. Campbell. The ranch owner reported that cow (ear tag No. G8) had a dystocia on March 10. The owner reported that his local veterinarian delivered a dead, male calf (Appendix B). The cow

was anorectic and died in the morning of March 16. The Simmental cow was 6 to 7 years old and weighed about 680 kg. Gross necropsy lesions were hemorrhages in the subcutaneous tissue and fascia surrounding the trachea. The right apical lung lobe was red, and the ventral aspects of both the left and right lung lobes were consolidated. The urinary mucosa was red and emphysematous, and the heart ventricles had scattered epicardial redness/hemorrhage. The liver Se concentration was 0.65 µg/g and would be considered deficient to marginal (Puls, 1990). The liver Cu concentration was 94 µg/g and would be considered adequate (Puls, 1990).

The histopathology lesions were hyperplasia of tracheal submucosal mucous glands, non-suppurative tracheitis, terminal emphysema, cystitis, lymphoid atrophy, and hemorrhagic aortitis (Stair and Kosanke, 1997). The hypertrophy and hyperplasia of the submucosal tracheal mucous glands were noted to be consistent with chronic obstructive pulmonary diseases (COPD). The histopathology diagnosis for cow No. 900566 follows:

- (1) Marked periaortic capillary leakage
- (2) Marked hemorrhagic aortitis
- (3) Terminal emphysema
- (4) Marked acute pulmonary capillary leakage
- (5) Hyperplasia of tracheal submucosal mucous glands
- (6) Mild subacute-to-chronic non-suppurative tracheitis
- (7) Marked diffuse subacute-to-chronic submucosal cystitis
- (8) Lymphoid atrophy.

On March 17, we observed the cattle and noted several calves with problems. One calf (ear tag No. D10) born to cow No. G199 on February 7, had a soft, pliable swelling in the mandibular area. The rectal temperature of the calf was 38.5°C. A heifer calf (ear tag No. D6) born to cow No. Y112 on January 29, had an abscess in the soft tissue along the left mandible that had drained. A male calf (ear tag No. Y18) born to cow No. G161 on February 7, had drainage from the right front knee joint. Another male calf (ear tag No. Y76) was born to cow No. G19 on February 20, had not been acting normally; the calf had harsh, raspy inspiration sounds in the right lung.

The ranch owner found a Charolais, female calf dead in the pasture on March 17. The owner reported that the calf had blood coming from the nose. The calf was 24 days old, she was born on February 22 to cow (ear tag No. G40). A necropsy was performed on March 18 at AEC. The calf weighed 59 kg and was in good body condition (Appendix B). The calf had froth in the trachea and wet, red lung lobes. Hemorrhages were observed on the epicardium of the left and

right ventricle. Fibrous adhesions were found between the liver and small intestine, liver and diaphragm, and the liver had scattered, small, white foci. The umbilical cord contained a reddish, thick fluid.

The histopathology findings were related to the septic omphalophlebitis; the hepatic abscesses and microthrombosis (DIC) would be related to the septic umbilical lesion (Stair and Kosanke, 1990). The histopathology diagnosis for calf No. 940236 follows:

- (1) Multiple hepatic abscesses with a purulent necrotizing hepatitis
- (2) Renal glomerular microthrombosis
- (3) Pulmonary microthrombosis with capillary leakage characterized by hemorrhage, edema and hyalin membrane formation
- (4) Thyroid microthrombosis
- (5) Submucosal ruminal hemorrhages
- (6) Acute purulent lymphadenitis involving primarily the mesenteric nodes
- (7) Lymphoid hypoplasia
- (8) Purulent (septic) omphalophlebitis
- (9) Intravascular bacterial aggregates
- (10) Cytoplasmic vacuolation involving the Gasserian ganglion.

The field team and the owner of Ranch A walked the pasture lease land, pasture that the Ranch A cattle would be placed on, adjacent to the pipeline leak. The field team was given a tour of the site in the afternoon by the petroleum company and an explanation of the ongoing remediation techniques. Later in the day, the pipeline was repaired and the termination of the clean-up initiated. The reconstruction of the river channels and banks would have to occur prior to the spring thaws and high river flow (SCLCC, 1994).

*March 17.* The field investigation team traveled to Ranch B to observe cattle and perform necropsies. The owners of Ranch B noted several calves had difficulty walking and observed that two calves were losing their hooves; the owners had not killed the calves so that necropsy data could be acquired. The field team took blood samples for serum chemistry analyses (Appendix D), and because of the pain and inevitable outcome of the loss of the hooves, killed and necropsied the calves. The gross necropsy data is found in Appendix B.

A female Red Angus calf was born in the barn to cow No. 2B on February 17, the minimal outside temperature measured in Sundre was -11°C (Appendix E). The calf (ID No. 940237) had bilateral sloughing of the hind feet. The serum glucose, BUN, creatinine, total protein, albumin,

Ca, Mg, and Fe concentrations were low as compared with the AEC normal ranges. The total bilirubin, 25 µmol/L, and direct bilirubin, 6 µmol/L, were elevated.

The calf (940237) was born twin to a bull calf and weighed 47 kg on March 18. The calf had little body fat and small, scattered redness for hemorrhages throughout all of the lung lobes. The tissue below the dewclaws on both rear feet was necrotic, with detachment at the joints. The liver Se, 3.8 µg/g, and liver Cu, 121 µg/g, concentrations would be considered adequate (Puls, 1990).

The histopathology lesions did not reveal any significant tissue damage (Stair and Kosanke, 1997). The histopathology findings for calf No. 940237 follows:

- (1) Multifocal purulent omasitis
- (2) Cytoplasmic vacuolation involving the neurons of the Gasserian ganglion.

Another heifer calf, born to cow No. 8B outside where the temperature ranged from -19 to -35°C on February 25, had bilateral sloughing of the hind feet and was also showing separation of tissue at the dewclaws of the right, front foot. The serum chemistry analyses revealed elevated glucose, BUN, P, Mg, Na, K, and Cl concentrations. The total protein, albumin, and creatinine concentrations were low. The amylase activity, 165 IU/L, was elevated above the normal AEC range.

The female calf (No. 940238) weighed 35 kg, had little body fat, and bilateral areas of consolidation in the apical lung lobes. The tissue below the dewclaw on the right front leg and rear legs was necrotic with pus. The liver Se, 1.5 µg/g, and liver Cu, 107 µg/g, concentrations would be considered adequate (Puls, 1990). The histopathology lesions included acute, fibrinopurulent bronchopneumonia and severe pododermatitis (Stair and Kosanke, 1997). The histopathology diagnosis for calf No. 940238 follows:

- (1) Acute fibrinopurulent bronchopneumonia
- (2) Lymphoid hypoplasia
- (3) Acute necrotizing purulent (septic) pododermatitis
- (4) Myeloid hyperplasia with a neutrophilic leukocytosis
- (5) Chronic/active tracheitis with hyperplasia of the submucosal glands
- (6) Cytoplasmic vacuolation involving the neurons of the Gasserian ganglion.

The ranch owners also reported that a cow had a large growth protruding from the vulva, the growth was coming off the left lateral vaginal wall.

*March 28-30. Ranch A.* The owner of Ranch A called on March 26 and reported that in the morning several cows were ataxic and struggled to get up, the cows were a Black Angus (ear tag

No. G145) a Black Angus with white socks (ear tag No. Y62) and a Charolais-cross cow (ear tag No. G95); the owner took videos of the cattle. The ranch owner had lost several calves and requested a field investigation to observe the staggering cows and necropsy the calves. On March 28 a field team consisted of M. Mostrom and C. Campbell went to the Ranch to perform necropsies and observe the cattle.

A heifer calf, born to cow No. G91 on February 26, was found dead in the pasture. A necropsy was done in the field (Appendix B). The calf (ID No. 940242) weighed 63 kg, had good body fat and muscle components and frozen ears. There was red consolidation of the right apical lung lobe and left dorsal lung lobes, with < 45% of the lung involved. A small (1.5 cm diameter) redness or hemorrhage was observed in the abomasal mucosa along the greater curvature and some of the intestinal contents in the jejunum were blood tinged. A milk curd was present in the abomasum and the rumen was full of hay, indicating that the calf was eating. The liver Se concentration was 0.8 µg/g (considered a deficient status), the liver Cu concentration was 574 µg/g (adequate status), and the liver Fe concentration was 363 µg/g (adequate status) (Puls, 1990). No sections of bone, bone marrow, or neural tissue were taken from this calf.

The histopathology lesions on submitted tissues were pulmonary congestion and capillary leakage, adrenal cortical congestion and hemorrhage, and a tracheitis with hyperplasia of the submucosal glands (Stair and Kosanke, 1997). The adrenal cortical vascular changes could be related to a stress reaction which in calves of this age may be caused by a bacteremia or toxemia. The histopathology diagnosis of calf No. 940242 follows:

- (1) Pulmonary congestion with capillary leakage characterized by both edema and hemorrhage
- (2) Adrenal cortical congestion with hemorrhage
- (3) Focal necrotizing tracheitis with hyperplasia of the submucosal glands.

The ranch owner gave the field team tissue samples for histoprocessing and histological examination from a Simmental/Angus cross, heifer calf (ID No. 940243). The calf was born to cow (ear tag No. G50) on March 15, and found dead on March 25-26. Many organs were not included in the tissue sampling and a definitive cause of death was not determined (Stair and Kosanke, 1997). The histological diagnosis on submitted tissues from the calf (ID No. 940243) follows:

- (1) Marked hepatic congestion
- (2) Marked pulmonary congestion with capillary leakage characterized by both edema and hemorrhage.

A cow (ear tag No. 208) was observed by the owner in estrus-like activity (bulling) about five days prior to calving. Two days prior to calving the owner reported that the cow had not developed an udder. The calf was born on March 27 at 17:00. The ranch owner pulled the calf, which he said was dead but appeared in a normal condition (calf was intact with no detachment of hair), and a greenish-colored placenta came with the calf. The calf (ID No. 940245) was necropsied on March 30 in an autolytic condition (Appendix B). The calf weighed about 59 kg and had fat around the kidneys and heart. The lungs did not float in water (no air in the alveoli); the calf was stillborn. Diagnostic immunohistochemistry tests in paraffin tissue sections against Bovine Herpes Virus Type 1 and BVD virus were negative. The liver Se concentration of 1.5 µg/g in a fetal calf would be considered a marginal status (Puls, 1990). The liver Cu, 686 µg/g, and liver Fe, 552 µg/g, concentrations would be considered adequate (Puls, 1990).

The histological lesions of calf No. 940245 included intratubular crystal formation in the kidney and pulmonary aspiration of meconium and squames, indicating fetal distress (Stair and Kosanke, 1997). The histopathologic diagnosis on calf No. 940245 follows:

- (1) Hepatocellular degenerative changes
- (2) Intratubular crystal formation in the renal cortex
- (3) Lymphoid immunostimulation
- (4) Pulmonary aspiration of meconium and squames.

The ranch owner gave us tissue samples of liver, fat, and kidney from a calf (ID No. 940246) found dead in the pasture. A local veterinarian conducted a post-mortem, and according to the ranch owner described a perforated abomasal wall and severe peritonitis. The calf, a Black Angus/Maine Anjou cross female, was born to cow (ear tag No. G127) on February 7. The histopathologic diagnosis on the tissue samples provided by the ranch owner for calf No. 930246 follows (Stair and Kosanke, 1997):

- (1) Centrilobular hepatocellular fatty change
- (2) Peripherolobular acute hepatocellular swelling
- (3) Renal ductal "cast formation".

A yearling steer (white tag No. 23) had a diarrhea and prolapsed rectum in early January. The local veterinarian diagnosed lice, coccidia and nematodirus, and repaired the rectum. The animal was placed in a pen and provided hay and pelleted grain. The animal continued to be gaunt and in March showed evidence of sloughing the hind feet. On March 30, we killed the steer with a bullet in the brain and necropsied the animal (ID No. 940247). The animal weighed about

386 kg and was sloughing the hind feet below the dewclaws (Appendix B). The dorso-caudal lung lobes were consolidated, the greater curvature of the abomasum had localized thickening of the mucosal surface, and the right ventricle epicardium had evidence of hemorrhage. Fibrous adhesions were observed between the urinary bladder and terminal colon. The liver Se concentration of 0.7 µg/g would be considered deficient (Puls, 1990). The liver Cu, 398 µg/g, and liver Fe, 328 µg/g, would be considered adequate (Puls, 1990).

The histopathologic lesions were a chronic, active bronchopneumonia with serous atrophy of fat (Stair and Kosanke, 1997). The histopathologic diagnosis of calf No. 940247 follows:

- (1) Non-suppurative interstitial nephritis
- (2) Chronic/active bronchopneumonia with the exudate composed of mucus, neutrophils, fibrin and serum
- (3) Serous atrophy of fat.

The field team observed a Black Angus cow (No. G145) that was alert, eating hay and pellets and drinking water. The cow tried to get up on the hind legs but staggered on the front knees. A blood sample was taken from the cow (ID No. 940244) for serum chemistry analyses (Appendix D) and an EDTA sample was taken for a WBC that was  $4.4 \times 10^9/L$ . The CPK activity, 913 U/L, was elevated (probably due to muscle damage from being recumbent and struggling to get up), The AST activity and creatinine concentration were elevated also. The Ca concentration, 1.98 mmol/L, was low. The ranch owner stated that a local veterinarian had examined the staggering cows initially and taken a blood sample from this cow and treated her intravenously. The cow was close to calving, so the ranch owner provided supportive treatment and attempted to prop the cow up for a period of time to prevent extensive muscle damage. The cow was treated with intravenous fluids and calcium, and given steroid to induce calving.

An Angus-Holstein cow with "white socks" (ear tag No. 62) who also staggered and was down on March 26 according to the ranch owner, was examined in the pasture. The cow was quite thin or cachectic and had yet to calve. She acted as if she was sore in the joints when walking; her gait was abnormal and stumbling. The caramel cow that the owner observed staggering on March 26, was in the pasture. The cow had a slightly abnormal gait when we got her up, she crossed her back legs when walking.

A heifer calf (ear tag No. D-29) was born on February 13 to cow ear tag No. G249. (She had exhibited ocular discharge in January). The cow was thin and not doing well; the temperature of the calf was 36.8°C. The animal was treated with antibiotics (recommended by a veterinary

pharmacologist for treatment of potential septic shock caused by *Enterococcus*). While taking samples on Ranch A, a cow (ear tag No. G240) prolapsed her vagina and uterus about three weeks post-calving. We observed a Charolais-cross calf that had contracted front legs. While conducting the field investigation, we heard several loud booms in the morning of March 30, and then smelled hydrocarbons.

The Ranch A owner had supplemented his cows with grain pellets that may have had Rumensin as an ingredient (Table 15). The additional protein was fed to the cows on the advise of the authors who have noted that in some toxicological problems increased protein in diets of cattle have mitigated clinical signs. The ranch owner fed about 2.2 kg (5 pounds) per head per day to the cows from late January through mid-April. A new shipment of pellets was delivered about 10 days prior to the incident staggering cows on March 26. A composite sample (ID No. 940248) of the pelleted feed was taken for monensin analyses. The monensin level was < 30 ppm, not a toxic level (Iowa State Diagnostic Laboratory, Ames, IA).

March 29. The field team of M. Mostrom and C. Campbell went to Ranch B to evaluate cattle and perform several necropsies. The team walked through the cows and calves which appeared to be in good condition. Yearling heifers continued to exhibit rough haircoats and did not appear to be gaining weight. The cow (tag No. 132) with the growth protruding from the vagina showed reduction in the protruding tissue. We examined two more calves that were sloughing hind feet. These animals were euthanized with a barbiturate and necropsied (Appendix B). A male Red Angus calf, born twin to a female calf (No. 940237) on February 17 to cow No. 2B, was losing the tissue below both rear fetlocks with some necrotic tissue observed below the right fetlock. The gross necropsy examination revealed a calf that weighed about 57 kg and good body condition. No gross lesions were observed in the lungs. The liver Se, 2.5 µg/g, liver Cu 179 µg/g, and liver Fe, 171 µg/g, concentrations would be considered adequate (Puls, 1990).

The histopathology lesions in calf No. 940249 were severe pododermatitis and thymic lymphoid atrophy; no neural tissue, bone, or bone marrow was submitted (Stair and Kosanke, 1997). The histopathology diagnosis on calf No. 940249 follows:

- (1) Thymic lymphoid atrophy
- (2) Severe acute purulent (septic) pododermatitis.

Table 15      Ingredient List on Pelleted Feed Given to Ranch A Cows

16% Cow Cubes (No. 248)		
Crude Protein	Min	16.0%
Crude Fat	Min	6.6%
Crude Fiber	Max	17.1%
Calcium	Actual	1.0%
Phosphorus	Actual	0.6%
Copper	Actual	33 mg/kg
Zinc	Actual	373 mg/kg
Manganese	Actual	230 mg/kg
Iodine	Actual	2.5 mg/kg
Cobalt	Actual	1.3 mg/kg
Vitamin A	Min	20000 IU/kg
Vitamin D	Min	2500 IU/kg
Vitamin E	Min	59 IU/kg

This feed contains added Selenium at 0.8 mg/kg. Manufactured by Triple M – Great West Feeds, Red Deer, Alberta.

A second calf (ID No. 940250) was born to dam No. 195 on February 12 when the minimum temperature was about -15°C (Appendix E). The calf weighed about 41 kg and had little evidence of body fat (Appendix B). The calf had scattered red consolidation of the ventral lung tissue and bilateral necrosis of tissue below the rear fetlocks. The liver Se concentration of 1.4 µg/g would be considered marginal to adequate (Puls, 1990). The liver Cu, 64 µg/g, and liver Fe, 194 µg/g, concentrations would be considered marginal (Puls, 1990).

The histopathology lesions in calf No. 940250 were interstitial nephritis and lymphoid hypoplasia; no neural tissue, bone or bone marrow was submitted (Stair and Kosanke, 1997). The histopathology diagnosis on calf No. 940250 follows:

- (1)      Multifocal non-suppurative interstitial nephritis
- (2)      Lymphoid hypoplasia.

Later in the evening we observed flaring, the flames might have been 100 feet into the air, to the northwest of Ranch B.

*April 4. Field investigation to Ranch A.* During the Easter holidays, M. Mostrom did the field investigation. A calf (ear tag No. D-29, ID No. 940251) which had been sick since late February,

continued to not gain weight (March 29); the calf was recumbent, very weak, and euthanized with a barbiturate prior to necropsy (Appendix B). The calf weighed about 64 kg and had a diffuse orangish-tan discoloration of the liver, no obvious lung lesions, and a small (<1 cm) dark red area on the left atrioventricular valve. The liver Se, 0.4 µg/g, liver Cu, 89 µg/g, and liver Fe, 97 µg/g would be considered deficient to marginal (Puls, 1990).

The histopathology lesions were thymic lymphoid atrophy, marrow myeloid hyperplasia, and renal cortical tubular nephrosis with cast formation (Stair and Kosanke, 1997). The latter lesion could be related to the extended use of antibiotics in this calf. The histopathologic diagnosis for calf No. 940251 follows:

- (1) Renal cortical tubular nephrosis with granular/cellular cast formation
- (2) Thymic lymphoid atrophy
- (3) Focal skeletal myofiber mineralization
- (4) Marrow myeloid hyperplasia
- (5) Cytoplasmic vacuolation involving the Gasserian ganglion.

Cow No. G145 (ID No. 940244) calved a large, live, bull calf on April 1. The cow had been recumbent for a week, and upon examination had damage to the left stifle joint which probably occurred when the animal attempted to rise. The decision was made by the ranch owner and M. Mostrom that the cow could not recover mobility, and was killed by a bullet to the brain. The animal was necropsied (Appendix B). Briefly, the cow had scattered areas of consolidation in the ventral portion of the lung lobes and emphysema of the dorso-caudal lobes. The heart had hemorrhage on the right atrioventricular valve and at the base of the papillary muscle in the right ventricle. The left stifle joint had ruptured ligaments and extensive fibrin and blood around the distal femur and proximal tibia. The rumen was full of hay and grain, the right horn of the uterus was enlarged with blood-tinged fluid, and the right adrenal gland had a fluid filled cyst in the medullary area. Diagnostic immunohistochemistry on a tissue section of kidney infiltrating cells stained positive for bovine immunoglobulin G (heavy and light chains). The liver Se, 1.1 µg/g, liver Cu, 214 µg/g, and liver Fe, 600 µg/g, concentrations would be considered marginal to adequate (Puls, 1990). The use of a bullet in the brain as euthanasia probably obscured any neural lesions that could explain the ataxia. The histopathology lesions included adrenocortical adenoma, interstitial plasmacytosis in the kidney, axonal swelling and demyelination of the trigeminal nerve and Gasserian ganglion. The histopathology diagnosis for cow No. 940244 follows:

- (1) Adrenocortical adenoma

- (2) Interstitial plasmacytosis in the renal cortex
- (3) Hepatocellular degenerative changes
- (4) Pulmonary aspiration hemorrhage, emphysema and atelectasis ("gunshot artefact")
- (5) Hemorrhagic meningitis (artefact due to gunshot)
- (6) Axonal swelling and demyelination of the trigeminal nerve accompanying the Gasserian ganglion
- (7) Cytoplasmic vacuolation involving the Gasserian ganglion
- (8) Tracheal submucosal gland hyperplasia.

In the authors' opinion, the cause of ataxia was not related to low Ca or Mg (note that in the AEC serum chemistry analyses, the Mg was within a normal range). The cow was treated with electrolytes and calcium and did not respond and the ataxia observed was atypical of a milk fever cow. Additionally, two other cows exhibited ataxia at the same time. The cow No. Y62 continued to stagger throughout the summer and fall and was culled from the herd; the cow No. G95 appeared to recover within a month.

*April 4. Field investigation of Ranch B.* The cows and calves were viewed by M. Mostrom. A bull calf (tag No. 167) (born January 30) was observed kicking at the abdomen, a clinical sign of abdominal discomfort. Another heifer calf (tag No. 120) (born February 13) had bloody, loose feces and was dehydrated. The latter calf died and was necropsied by the local veterinarian. The owner of Ranch B saved tissues in buffered formalin from the calf (ID No. 940309) and requested histopathology. The lesions observed in the submitted tissues included a severe acute tracheitis and bronchopneumonia, lymphoid hypoplasia of the spleen and lymph node, and coccidial colitis. The histopathology diagnosis for calf No. 940309 follows:

- (1) Centrilobular hepatocellular necrosis
- (2) Renal cortical interstitial multifocal fibrous connective tissue deposition (scarring)
- (3) Pulmonary congestion
- (4) Acute fibrinopurulent bronchopneumonia and tracheitis
- (5) Tracheal submucosal gland hyperplasia
- (6) Marked splenic lymphoid follicular hypoplasia
- (7) Lymph nodes, medullary edema, mild
- (8) Lymph nodes, moderate-to-marked lymphoid follicular hypoplasia
- (9) Colitis, coccidial, capillary leakage.

*April 6. Telephone conversation with Ranch A owner.* The owner of Ranch A reported that he had about 40 to 50 calves out of 250 exhibiting abnormal rear leg gaits. Cow No. Y62 had a live calf, but continued to have an abnormal gait at times.

*April 7. Telephone conversation with Ranch A owner.* The owner of Ranch A stated that the previous evening he observed a plume of gaseous material, that had a greenish cast and smelled of chlorine, move through the ranch cattle yard. A cow (ear tag No. B38) staggered the morning of April 7 and calved. The owner took videos of the cattle on the morning of April 7. The owner reported that the calf from cow No. B38 was dead and necropsied by a local veterinarian. Tissues from the calf (ID No. 940290) were taken by the ranch owner for histopathology evaluation. The appearance of the tissues was within normal limits (Stair and Kosanke, 1997).

*April 14-15. Field investigation to Ranch A.* The field trip was made by M Mostrom and C. Campbell. A male calf (ear tag No. Y49 or ID No. 940288) was born on February 15 to cow No. Bk 44. The calf was found dead in the pasture on April 13 by the ranch owner who had not observed any abnormal clinical signs in the calf. The calf weight was about 114 kg and was in good body condition (Appendix B). The calf had hemorrhage on the right ventricle epicardium and hemorrhage at the base of the aorta. A 2.5 to 3 cm hole was observed in the abomasal wall with a few strands of fibrin noted in the peritoneal cavity. The liver Se concentration of 0.7 µg/g would be considered marginal and the liver Cu concentration of 107 µg/g would be considered adequate (Puls, 1990).

The histopathology findings included a perforating abomasal ulcer, splenic lymphoid hypoplasia, and tracheal submucosal gland hyperplasia (Stair and Kosanke, 1997). The changes in the lungs and trachea were considered indicators of a respiratory irritant acting over a period of time. The histopathology diagnosis of calf No. 940288 follows:

- (1) Chronic fibrous pleuritis
- (2) Pulmonary congestion and lymphoid nodular hyperplasia
- (3) Splenic lymphoid hypoplasia
- (4) Colloidal degeneration in thyroid follicles and acute hemorrhagic thyroiditis
- (5) Tracheal submucosal gland hyperplasia
- (6) Perforating abomasal ulcer
- (7) Lymphoid hypoplasia
- (8) Adrenocortical congestion with hemorrhage
- (9) Cytoplasmic vacuolation involving the Gasserian ganglion.

A calf (ear tag No. Gr D-63 or ID No. 940293) was observed to be slow in actions and had a slight diarrhea. The rectal temperature was 39.6°C and the calf had increased inspiratory lung sounds. Blood was taken for serum chemistry analyses (Appendix D). The serum BUN, creatinine, total protein, albumin, P, and Mg concentrations were low. The activities of LDH, CPK, AST, ALT, and amylase were elevated. The animal was treated with antibiotics. Another calf, a twin heifer calf with ear tag No. D-82 was born on March 6 to cow No. G232; the calf (ID No. 940307) had a hard, swollen left stifle joint.

Other problems were observed in calves. A Longhorn heifer calf (ear tag No. D-100) (born on March 23 to cow No. Bk 46) exhibited slight tremors when standing. Another heifer calf (ear tag No. D-75) (born on February 28 to cow No. Bk37) had a marked inspiratory "honk", with the noise primarily located in the trachea. A male calf (ear tag No. Y76 or ID No. 940296) (born on February 20 to cow No. G19, a cow that had exhibited bloody nasal discharge in January (Table 10)), was very stiff with a swollen right front leg.

A cow (ear tag No. Bk38 or ID No. 940294) was showing estrus-like activity (bulling) and had mastitis in the rear quarters. A blood sample was taken for serum chemistry evaluation (Appendix D). The BUN, total and direct bilirubin concentrations were elevated. The concentrations of total protein, albumin, Ca, Na, K, Cl, and Fe concentrations were low. The activities of LDH, CPK, AST, GGT, and amylase were elevated. The animal was treated with antibiotics.

Several other cows were exhibiting estrus-like activity, including a cow No. Y103 or ID No. 940295. The cow was palpated by rectum and determined to be several weeks from calving. A blood sample was taken and the results are provided in Appendix D. The BUN, albumin, Mg, and Cl concentrations were low. Cow (ear tag No. G53) was bulling (she had exhibited dyspnea in January (Table 10) and she would calve April 17).

The ranch owner took a video of cow (ear tag No. G226) dragging the right hind leg; we observed the video.

*April 15. Field investigation of Ranch B.* The rancher had five older bulls and one yearling bull (about 600 kg) to put with cows this year. The older bulls consisted of four 4 year-olds, and one 3 year-old. The owner had kept back 25 heifers now weighing about 318 kg, the majority of the heifers were cycling. However, in another pen of six heifers and two steers, none of the heifers were cycling. We observed a cow (tag No. 55) with an abnormal gait, she was walking up on her

front feet cow tag No. 155 was lame. One cow (tag No. 14B) had a left eye infection. The owner reported that a cow (tag No. 58B) was not pregnant.

April 18 - 19. Field investigation of Ranch A. The investigation was done by M. Mostrom and C. Campbell. The ranch owner was processing calves and having bull semen evaluation conducted by the local veterinarian. We observed problems in several calves. A Maine Anjou calf No. Y146, born on April 10 to cow No. Bk4, had a slight abnormality in the gait, he acted as if the "joints were loose". The calf No. D100 acted normal today (April 14). Another calf (tag No. Y120) born March 14 to cow No. G95, was lethargic. A calf (tag No. D10) (born on February 7 to dam No. G199, a cow that had exhibited ocular discharge in January (Table 10)), that had displayed a swollen throat, died.

We examined the cows that staggered on March 26. The Charolais cross cow (No. G95) appeared normal, while the Angus cow No. Y62 continued to have an abnormal gait.

A Charolais cross calf (tag No. Y76 or ID No. 940296) was very stiff, the front carpal joints and the left stifle joint were swollen and hard on palpation. The prognosis was poor and the ranch owner decided to have the calf euthanized and necropsied (Appendix B). The calf weighed about 105 kg and had erosion of the articular cartilage on the base of the left femur. The joint cavity had approximately 120 mL of a cloudy, red fluid. The left popliteal lymph node was enlarged. Diagnostic immunohistochemistry tests against *Leptospira* in a kidney section was negative, sections of lymph node and brain were negative against both Bovine Herpes Virus Type 1 and BVD viruses, but were slightly positive to positive for *Listeria monocytogenes*. The liver Se, 1.6 µg/g, and liver Cu, 190 µg/g, would be considered adequate (Puls, 1990).

The histopathology lesions were nephritis, lymphocytic-neutrophilic meningoencephalitis, and lymphocytic optic perineuritis and peripheral neuritis, and an arthritis and synovitis (Stair and Kosanke, 1997). The histopathology diagnosis for calf No. 940296 follows:

- (1) Enteritis, moderate, parasitic
- (2) Nephritis, interstitial, non-suppurative
- (3) Nephritis, tubular, neutrophilic and necrotic
- (4) Renal tubular and ductal cast formation
- (5) Hemorrhagic ligament. Articular (cartilage) erosion
- (6) Fibrinopurulent and hemorrhagic arthritis, synovitis-subsynovitis
- (7) Moderate lymphocytic-neutrophilic meningoencephalitis and multifocal (non-suppurative) lymphocytic perivasculitis

- (8) Lymphocytic (non-suppurative) optic perineuritis and peripheral neuritis
- (9) Cytoplasmic vacuolation involving the Gasserian ganglion.

On the afternoon of April 19, we observed a calf (ear tag No. 63) stumbling and falling down when the cows were being moved to a new pasture. The calf could rise on the hind legs but walked on the front knees, putting the nose into the ground. When the calf finally got up, it wobbled and crossed the back legs when walking away.

With the ranch owner, we walked the cattle pasture adjacent to the pipeline reclamation project.

*April 22. Field investigation of Ranch A.* A field trip was made by M. Mostrom and C. Campbell. The ranch owner reported that calf No. Y146 (April 18) had continued to show pronounced gait action in the rear legs. On April 20, the calf was found recumbent in the pasture in opisthotonus and had constant lateral motion of the pupil (lateral nystagmus). The owner videotaped the calf. The calf was treated with antibiotic and thiamine, but showed no improvement. The calf (ID No. 940300) died on April 22, and was necropsied within five hours after death (Appendix B). The calf weighed about 114 kg and had scattered areas of redness in all of the lung lobes. When the cranium was opened, about 10 mL of blood-tinged cerebrospinal fluid was around the brain. A blood-tinged fluid filled cyst (about 5 mL) was observed on the dorsal aspect of the cerebellum. The liver Se, 1.1 µg/g, and liver Cu, 333 µg/g, concentrations would be considered adequate for this age of calf (Puls, 1990).

The histopathology lesions were lymphoid hypoplasia and a cerebellar neuroblastoma (Stair and Kosanke, 1997). The histopathology diagnosis for calf No. 940300 follows:

- (1) Pulmonary capillary leakage primarily characterized by edema
- (2) Lymphoid hypoplasia
- (3) Cerebellar neuroblastoma.

*April 22. Field investigation of Ranch B.* A field trip was made by M. Mostrom and C. Campbell at the request of the ranch owner to examine and necropsy a cow exhibiting nervous system signs. The ranch owner stated that on April 20 he had a 13 year-old cow (tag No. 84) that developed acute clinical signs of paralysis of the left side of the face, the left ear was down, the tongue hung out of her mouth on the left side, and she walked in circles. A local veterinarian examined the cow. The cow had not improved on April 22, and because she could not eat or drink, the ranch owner requested that she be euthanized and necropsied (Appendix B). We noted that her temperature was 39°C, the left eye had purulent discharge and did not appear to have a

blinking reflex; however, the cow felt pain on the left side of the face. The cow (ID No. 940299) was leaning to the right side, but no longer was circling.

On gross necropsy, the lungs were emphysematous. Endocardial hemorrhage was observed in the left and right ventricles, the left eye had the appearance of a corneal ulcer, and the cerebrospinal fluid was blood tinged. A rabies differential diagnosis was ruled out. The liver Se concentration, 1.2 µg/g, would be considered marginal to adequate, the liver Cu concentration, 87 µg/g, would be considered marginal, and the serum vitamin E concentration of <0.25 µg/mL and plasma Zn concentration of 608 ng/mL would be considered deficient (Puls, 1990; Puls, 1994).

The histopathology lesions included tracheal submucosal gland hyperplasia, bone marrow atrophy, membranous glomerulonephritis, and a non-suppurative meningitis and encephalitis (Stair and Kosanke, 1997). The lymphocytic perivascular cuffing in the cerebrum, cerebellum, and Gasserian ganglion would be consistent with a viral etiology, but no inclusion bodies were demonstrated. The histopathology diagnosis for cow No. 940299 follows:

- (1) Membrous glomerulonephritis and non-suppurative interstitial nephritis
- (2) Terminal emphysema
- (3) Tracheal submucosal gland hyperplasia
- (4) Medullary hemosiderosis of the mesenteric lymph nodes
- (5) Bone marrow atrophy
- (6) Non-suppurative Gasserian ganglioneuritis
- (7) Non-suppurative meningitis and encephalitis
- (8) Corneal erosion.

A two year-old bull had an acute onset of pneumonia which was treated with antibiotics and seemed to respond was examined by the field team. The bull was continuing to lose weight according to the owner.

April 23. A 6 week-old, Charolais cross calf (ear tag No. Y18 or ID No. 940298) was born to cow No. G161. The calf had a history of a right carpal joint infection. The ranch owner found the calf dead in the pasture: the ranch owner necropsied the animal and placed tissue samples in buffered formalin for histopathology. The owner described a hole ("ulcer") in the abomasum and noted gastrointestinal fluids in the peritoneal cavity (Appendix B). The histopathology lesions included a perforating gastric ulcer and fibrinopurulent peritonitis, subacute non-suppurative tracheitis, splenic red pulp anemia and necrosis, and lymphoid hypoplasia (Stair and Kosanke, 1997). The histopathology diagnosis of calf No. 940298 follows:

- (1) Subpleural and interlobular emphysema
- (2) Catarrhal bronchitis
- (3) Splenic red pulp, anemia
- (4) Splenic red pulp, diffuse necrosis
- (5) Subacute non-suppurative tracheitis
- (6) Lymphoid hypoplasia
- (7) Lymph node, severe diffuse congestion and hemorrhage
- (8) Perforating gastric ulcer
- (9) Fibrinopurulent peritonitis.

*April 26. Ranch investigation to Ranch A.* A field trip was made by M. Mostrom and C. Campbell. A three day-old Simmental-Hereford cross bull calf (tag No. Y157) born to cow No. G23, was found dead without any clinical signs. The calf had been dead about 18 hours prior to necropsy (Appendix B). The calf weighed about 45 kg and had fat around the kidneys. Scattered areas of hemorrhage were observed in all lung lobes. About 4 to 5 mL of blood-tinged fluid was found in the pericardial sac. Bacteriology culture of liver, lung, spleen, and kidney revealed the growth of mucoid beta hemolytic colonies of gram positive short rods, which was identified as *A. pyogenes*. The liver Se, 2.6 µg/g, and liver Cu, 459 µg/g, concentrations would be considered adequate (Puls, 1990).

The histopathology lesions were acute pneumonia and microthrombosis, adrenal cortical hemorrhage and microthrombosis, lymphoid hypoplasia, and tracheal submucosal gland hyperplasia (Stair and Kosanke, 1997). The generalized DIC was suggestive of a septicemia. The histopathology diagnosis of calf No. 940306 follows:

- (1) Acute necrotozing (aspiration) pneumonia with capillary leakage and microthrombosis
- (2) Adrenal cortical hemorrhage with corticomedullary microthrombosis
- (3) Lymphoid hypoplasia
- (4) Tracheal submucosal gland hyperplasia.

A calf (tag No. D-82 or ID No. 940307) and born twin to a bull calf from cow No. G232, had difficulty walking because of an enlarged left stifle and was euthanized with barbiturate. Prior to euthanasia, blood samples were taken. The serum chemistry analyses are listed in Appendix D. Briefly, the serum BUN, creatinine, total protein, albumin, Ca, Mg, and Fe were low. The activities of CPK and AST were elevated.

The seven week-old calf weighed about 100 kg (Appendix B). Both right and left lung lobes had fibrous adhesions to the thoracic wall and scattered abscesses (5 to 15 mm) in the ventral aspect of the lung lobes. The left stifle had about 100 mL of a yellowish-green purulent material and hypertrophy of the joint capsule. Diagnostic immunohistochemistry on liver sections were negative against *Salmonella* sp. The liver Se, 0.95 µg/g, and liver Cu, 58 µg/g, concentrations would be considered marginal (Puls, 1990). The stifle joint was cultured and grew gram positive short rods that would be considered *A. pyogenes*. The serum vitamin E concentration of <0.25 µg/mL would be considered deficient (Puls, 1994).

The histopathology lesions were bronchopneumonia, cholecystitis, thyroid follicular atrophy, lymph node hypoplasia, granulomatous hepatitis, and arthritis (Stair and Kosanke, 1997). The histopathology diagnosis of calf No. 940307 follows:

- (1) Subacute-to-chronic active cholecystitis
- (2) Moderate-to-marked lymphoreticular nodular granulomatous hepatitis
- (3) Chronic/acute abscessing bronchopneumonia
- (4) Fibrinopurulent, necrotizing, abscessing and septic synovitis-arthritis
- (5) Thymic atrophy, marked
- (6) Thyroid follicular atrophy and decrease in colloid
- (7) Lymph node, hypoplasia
- (8) Lymph node, lymphoid follicular necrosis and lymphoid follicular hypoplasia (two of the four lymph nodes)
- (9) Lymph node, medullary edema
- (10) Lymph node sinusoidal hemorrhage.

April 26. Ranch investigation to Ranch B. The field team of C. Campbell and M. Mostrom observed that the two year-old bull (ID No. 940278) continued to lose weight and had stiff hind legs. A cow (tag No. 98) also had an abnormal gait with stiff hind legs. The ranch owner reported that a calf (No. 123 - see February 9 for calf ID No. 940123) had died on April 25; several weeks prior to the calf's death, the ranch owner had smelled a chemical odor. Tissue samples were taken by the owner at the time of death (Appendix B). Lung tissue sections examined by immunohistochemistry were positive to *Hemophilus somnus*. The histopathology lesions were splenic lymphoid hypoplasia, adrenocortical hemorrhage and congestion, bronchopneumonia, and epicarditis (Stair and Kosanke, 1997). It was believed that the splenic lymphoid hypoplasia

preceded the pleuritis and bronchopneumonia, which caused the death of the calf. The histopathology diagnosis of calf No. 940308 follows:

- (1) Splenic lymphoid follicular hypoplasia
- (2) Adrenocortical hemorrhage and congestion with fibrin microthrombi
- (3) Acute hemorrhagic, necrotizing, septic and fibrinopurulent bronchopneumonia and pleuritis with abscess formation
- (4) Subacute epicarditis.

*May 4-5.* A field team of M. Mostrom and C. Campbell participated in the May 4-5 investigations. Because of the unusually high death losses in calves on these two ranches and the potential for lack of protection by colostrum, we decided to determine if the calves had evidence of absorbing immune substance from colostrum. Blood samples were taken from recently calved dams and their calves and hematology and blood serum chemistries, particularly the GGT concentrations, and immunoglobulin concentrations (alpha, beta, gamma immunoglobulins, total protein, albumin and albumin/globulin ratio) were evaluated. We also took colostrum/milk samples from cows, but these samples were not analyzed for immunogloublin concentration because of the cost factor. Both ranch owners tried to ensure that the calves sucked the dam or were given more than two liters of colostrum by four to five hours post-birth.

Trace mineral analyses were performed on the blood samples. Whole blood selenium concentrations were determined on the cows: selenium, copper, and zinc concentrations were determined on plasma and vitamin E (alpha tocopherol) concentrations were determined in serum from the cows and calves. As a comparison, we took blood samples on May 3 from several cows and their calves in the AEC herd. Previously, we attempted to take blood samples from AEC calves prior to suckling (collection day <1) or in some instances we collected blood from AEC calves following their first suckling or colostrum transfer.

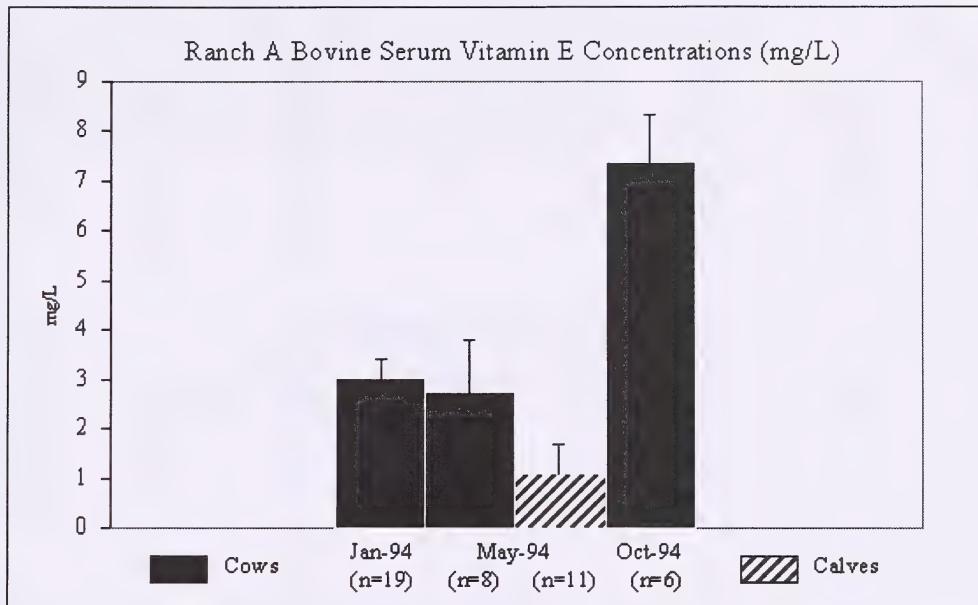
*Field investigation on Ranch A.* The dams and their calves bled on Ranch A are listed in Table 16. The serum vitamin E concentrations are also listed. The serum vitamin E concentrations in the calves would be considered normal (Puls, 1994). Adequate vitamin E concentrations in adult cows should be greater than 3 mg/L, serum vitamin E concentrations less than 3.0 mg/L would be considered marginal, and less than 2.0 mg/L would be inadequate to prevent myopathies (cows No. 940342 and 940339) (Puls, 1994). Figure 3 summarizes in bar graph form the serum vitamin E concentrations in Ranch A animals in 1994.

Table 16 Description of Animals Bled on May 5, 1994 on Ranch A

AEC No.	Calf No.	Sex	Age/Date of Birth	Dam No.	Serum Vit. E (mg/L)
940327	Y154	M	94.04.20	G162	0.6
940328	Gr D-119	F	94.04.23	G122	1.3
940329	Y158	M	94.04.22	G101	1.2
940330	Y155	M	94.04.22	Bk6	0.8
940331	Y160	M	94.04.28	G211	0.8
940332	Y156	M	94.04.22	G106	0.9
940333	Gr D-121	F	94.04.29	G66	0.7
940334	Gr D-118	F	94.04.29	G18	0.8
940335	Gr D-122	F	94.04.27	G49	0.6
940336	Gr D-120	F	94.04.24	G45	2.1
940337	Y161	M	94.05.02	Y103	
940338	Gr D-123	F	94.04.29	G36	2.3
940295	Y103	F		-cow	2.2
930607	G18	F		-cow	
911075	G66	F		-cow	3.1
940050	G106	F		-cow	3.3
940339	G122	F		-cow	1.8
940340	G101	F		-cow	4.5
940341	Bk6	F		-cow	3.2
940342	G211	F		-cow	1.3
940343	G45	F		-cow	2.9
940344	G49	F		-cow	2.0
940345	G162	F		-cow	2.5
940346	G36	F		-cow	3.7

The hematology and serum chemistry raw data on the Ranch A animals are listed in Appendix D. A summary of some of the serum chemistry data is presented in Table 17, with the inclusion of data from AEC cows, young or neonate calves and older calves. The serum immunoglobulin (alpha, beta and gamma) and albumin data on Ranch A cows and calves

Figure 3 Serum Vitamin E Concentrations (Mean  $\pm$  SD) in Ranch A Animals in 1994



bled on May 5 is listed in Table 18. For comparison purposes, data from AEC (control) animals (and the age of the calf when the sample was taken) were included in the table. Figure 4 is a plot using linear regression of the gammaglobulin concentrations in g/L (Y-axis) versus age of the calves (age in days) from the AEC, Ranch A and Ranch B herd. As expected, the initial gammaglobulin concentrations reflect the intake of colostrum in the AEC data on day 1 (some calves had sucked the cow and other calves were bled on day 1 immediately after birth and before sucking the cow). The decreasing concentration of gammaglobulin (IgG) as the calf ages likely reflects the half-life of IgG (17-22 days). Several of the Ranch A young calves had very low IgG values, ID No. 940331, a seven day-old calf, had a IgG concentration of 2.7 g/L [the GGT activity was 91 U/L] and No. 940337, a 3 day-old calf, had a IgG concentration of 1.9 g/L [the GGT activity was 29 U/L]. At 48 hours-of-age, serum concentrations of less than 10 g/L are consistent with failure of passive transfer (Parish, 1996). Levels of GGT are indicative of immunoglobulin absorption, as GGT is present in colostrum at levels more than 300 times that normally found in serum, and GGT levels in 1 to 2 day-old calves should be greater than 300 U/L (Parish, 1996). Figure 5 summarizes in bar charts the concentrations (g/L) of globulin, albumin, the albumin/globulin ratio, and total protein in calves and cows from Ranch A; the AEC data is presented for comparison. The trace mineral data on the cow and calves is provided in Appendix E.

Table 17 Summary of Clinical Pathology Data from Alberta Environmental Centre Cattle,  
Ranch A and Ranch B Cows and Calves

Parameter Location	<u>CREATININE PHOSPHOKINASE (CPK)</u>						
	AEC neonate	AEC calf	AEC cow	Ranch A <sup>1</sup> calf	Ranch A <sup>1</sup> cow	Ranch B <sup>2</sup> calf	Ranch B <sup>2</sup> cow
Age							
Mean	593	260	162	86	129	148	170
Max <sup>3</sup>	2840	1600	281	126	326	299	269
Min <sup>4</sup>	61	44	108	52	87	68	108
Std <sup>5</sup>	817	383	50	23	63	79	55
n <sup>6</sup>	16	13	17	12	12	8	8

Parameter Location	<u>LACTIC ACID DEHYDROGENASE</u>						
	AEC neonate	AEC calf	AEC cow	Ranch A calf	Ranch A cow	Ranch B calf	Ranch B cow
Age							
Mean	728	915	1065	715	907	777	1282
Max	1224	1420	1234	999	1050	878	1704
Min	436	648	870	528	766	625	987
Std	200	197	109	111	75	93	278
n	16	13	17	12	12	8	8

Parameter Location	<u>ASPARTATE AMINOTRANSFERASE (AST)</u>						
	AEC neonate	AEC calf	AEC cow	Ranch A calf	Ranch A cow	Ranch B calf	Ranch B cow
Age							
Mean	60	51	77	41	85	48	91
Max	138	121	86	53	116	65	111
Min	13	32	67	33	72	38	74
Std	31	22.1	5.3	5.3	12	9.8	13
n	16	13	17	12	12	8	8

Parameter Location	<u>ALANINE AMINOTRANSFERASE (ALT)</u>						
	AEC neonate	AEC calf	AEC cow	Ranch A calf	Ranch A cow	Ranch B calf	Ranch B cow
Age							
Mean	12	9.3	25	9.7	23.5	9	26
Max	22	19	36	19	28	19	35
Min	5	6	6	6	14	6	18
Std	4.3	3.1	7.3	3.5	4.4	4.4	6
n	16	13	17	12	12	8	8

<sup>1</sup> Blood samples taken in 1994 from neonatal calves, older calves (12-50 days of age) and cows

<sup>2</sup> Blood samples taken in 1994

<sup>3</sup> Maximum value

<sup>4</sup> Minimum value

<sup>5</sup> Standard deviation of the mean

<sup>6</sup> Number of observations

Table 17

Summary of Clinical Pathology Data from Alberta Environmental Centre Cattle,  
Ranch A and Ranch B Cows and Calves

Parameter Location	<u>ALKALINE PHOSPHATASE (ALP)</u>						
	AEC	AEC	AEC	Ranch A <sup>1</sup>	Ranch A <sup>1</sup>	Ranch B <sup>2</sup>	Ranch B <sup>2</sup>
Age	neonate	calf	cow	calf	cow	calf	cow
Mean	310	568	127	467	36	400	76
Max <sup>3</sup>	679	760	590	798	73	818	155
Min <sup>4</sup>	107	344	32	195	17	132	38
Std <sup>5</sup>	167	152.8	147	221	16	255	40
n <sup>6</sup>	16	13	17	12	12	8	8

Parameter Location	<u>GAMMA GLUTAMYLTRANSFERASE</u>						
	AEC	AEC	AEC	Ranch A	Ranch A	Ranch B	Ranch B
Age	neonate	calf	cow	calf	cow	calf	cow
Mean	1160	77	17	104	17	57	17
Max	4690	214	24	266	27	183	22
Min	7	17	11	29	12	20	13
Std	1200	65	2.7	69	4	60	3
n	16	13	17	12	12	8	8

Parameter Location	<u>AMYLASE</u>						
	AEC	AEC	AEC	Ranch A	Ranch A	Ranch B	Ranch B
Age	neonate	calf	cow	calf	cow	calf	cow
Mean	85	85	112	84	73	76	87
Max	124	113	258	108	105	105	111
Min	61	58	74	60	46	52	69
Std	18	16.1	48.2	15	14	18	16
n	16	13	17	12	12	8	8

Parameter Location	<u>TOTAL BILIRUBIN</u>						
	AEC	AEC	AEC	Ranch A	Ranch A	Ranch B	Ranch B
Age	neonate	calf	cow	calf	cow	calf	cow
Mean	19	5	4	4	3.5	5.8	3
Max	56	8	6	6	8	18	7
Min	3	3	1	1	1	1	4
Std	13	1.7	1.5	1.5	1.9	5	2
n	16	13	17	12	12	8	8

<sup>1</sup> Blood samples taken in 1994 from neonatal calves, older calves (12-50 days of age) and cows

<sup>2</sup> Blood samples taken in 1994

<sup>3</sup> Maximum value

<sup>4</sup> Minimum value

<sup>5</sup> Standard deviation of the mean

<sup>6</sup> Number of observations

Table 17 Summary of Clinical Pathology Data from Alberta Environmental Centre Cattle,  
Ranch A and Ranch B Cows and Calves

Parameter Location	<u>GLUCOSE</u>						
	AEC	AEC	AEC	Ranch A <sup>1</sup>	Ranch A <sup>1</sup>	Ranch B <sup>2</sup>	Ranch B <sup>2</sup>
Age neonate		calf	cow	calf	cow	calf	cow
Mean	5.3	6.4	4.0	5.8	4.2	5.5	4.1
Max <sup>3</sup>	9.0	7.4	4.6	8.4	5.3	7.3	4.8
Min <sup>4</sup>	2.4	5.5	3.8	3.5	3.2	3.8	3.6
Std <sup>5</sup>	1.8	0.6	0.27	1.3	0.6	1.1	0.5
n <sup>6</sup>	16	13	17	12	12	8	8

Parameter Location	<u>BLOOD UREA NITROGEN</u>						
	AEC	AEC	AEC	Ranch A	Ranch A	Ranch B	Ranch B
Age neonate		calf	cow	calf	cow	calf	cow
Mean	3.2	2.9	3.5	4	3.2	3.4	2.5
Max	5.3	5.7	4.7	7.8	4.1	4.9	3.8
Min	2.1	1.7	2.5	1.9	2.2	2.0	1.6
Std	0.9	0.96	0.55	1.9	0.98	0.97	0.7
n	16	13	17	12	12	8	8

Parameter Location	<u>CREATININE</u>						
	AEC	AEC	AEC	Ranch A	Ranch A	Ranch B	Ranch B
Age neonate		calf	cow	calf	cow	calf	cow
Mean	211	115	141	123	165	105.5	131
Max	353	127	165	164	224	111	145
Min	109	100	125	99	132	88	108
Std	90	7.8	14.4	17.7	30.2	10.9	12
n	16	13	17	12	12	8	8

Parameter Location	<u>URIC ACID</u>						
	AEC	AEC	AEC	Ranch A	Ranch A	Ranch B	Ranch B
Age neonate		calf	cow	calf	cow	calf	cow
Mean	46	43	53	68.5	44.4	50.6	49
Max	82	59	59	90	73	72	69
Min	26	36	40	29	24	37	39
Std	15.1	7.7	5.8	18.7	13.7	11.8	10
n	16	13	17	12	12	8	8

<sup>1</sup> Blood samples taken in 1994 from neonatal calves, older calves (12-50 days of age) and cows

<sup>2</sup> Blood samples taken in 1994

<sup>3</sup> Maximum value

<sup>4</sup> Minimum value

<sup>5</sup> Standard deviation of the mean

<sup>6</sup> Number of observations

Table 17 Summary of Clinical Pathology Data from Alberta Environmental Centre Cattle,  
Ranch A and Ranch B Cows and Calves

Parameter Location	<u>CALCIUM</u>						
	AEC	AEC	AEC	Ranch A <sup>1</sup>	Ranch A <sup>1</sup>	Ranch B <sup>2</sup>	Ranch B <sup>2</sup>
Age	neonate	calf	cow	calf	cow	calf	cow
Mean	2.81	2.49	2.38	2.65	2.14	2.6	2.34
Max <sup>3</sup>	3.08	2.75	2.51	3.10	2.29	2.83	2.51
Min <sup>4</sup>	2.55	2.32	2.25	2.36	1.91	2.44	2.06
Std <sup>5</sup>	0.13	0.12	0.09	0.18	0.12	0.14	0.13
n <sup>6</sup>	16	13	17	12	12	8	8

Parameter Location	<u>PHOSPHORUS</u>						
	AEC	AEC	AEC	Ranch A	Ranch A	Ranch B	Ranch B
Age	neonate	calf	cow	calf	cow	calf	cow
Mean	2.48	3.38	1.19	3.27	1.14	3.09	1.53
Max	2.95	3.78	1.63	3.73	2.55	3.71	2.12
Min	1.86	2.90	0.84	2.09	0.78	2.64	1.30
Std	0.27	0.25	0.21	0.41	0.47	0.36	0.26
n	16	13	17	12	12	8	8

Parameter Location	<u>MAGNESIUM</u>						
	AEC	AEC	AEC	Ranch A	Ranch A	Ranch B	Ranch B
Age	neonate	calf	cow	calf	cow	calf	cow
Mean	0.90	0.79	0.83	0.82	0.76	1	0.95
Max	1.09	0.82	0.92	0.97	1.80	1	1.92
Min	0.23	0.76	0.73	0.67	0.35	1	0.67
Std	0.24	0.02	0.05	0.08	0.35	0	0.40
n	16	13	17	12	12	8	8

Parameter Location	<u>TOTAL PROTEIN</u>						
	AEC	AEC	AEC	Ranch A	Ranch A	Ranch B	Ranch B
Age	neonate	calf	cow	calf	cow	calf	cow
Mean	56	61	73	62.6	73	60	78
Max	79	69	78	79	78	75	85
Min	36	55	68	44	67	53	71
Std	13.5	4.4	3.15	10.6	3.35	7.06	4.7
n	16	13	17	12	12	8	8

<sup>1</sup> Blood samples taken in 1994 from neonatal calves, older calves (12-50 days of age) and cows

<sup>2</sup> Blood samples taken in 1994

<sup>3</sup> Maximum value

<sup>4</sup> Minimum value

<sup>5</sup> Standard deviation of the mean

<sup>6</sup> Number of observations

Table 17

Summary of Clinical Pathology Data from Alberta Environmental Centre Cattle,  
Ranch A and Ranch B Cows and Calves

Parameter Location	<b>ALBUMIN</b>						
	AEC neonate	AEC calf	AEC cow	Ranch A <sup>1</sup> calf	Ranch A <sup>1</sup> cow	Ranch B <sup>2</sup> calf	Ranch B <sup>2</sup> cow
Age							
Mean	22.4	31	34	25.4	31.3	28.4	31.7
Max <sup>3</sup>	26	35	37	28	34	32	37
Min <sup>4</sup>	20	29	31	21	26	23	29
Std <sup>5</sup>	1.69	2.1	1.6	1.8	2.5	3	2.9
n <sup>6</sup>	16	13	17	12	12	8	8

Parameter Location	<b>A-G RATIO</b>						
	AEC neonate	AEC calf	AEC cow	Ranch A calf	Ranch A cow	Ranch B calf	Ranch B cow
Age							
Mean	0.83	1.10	0.88	0.76	0.76	0.98	0.70
Max	1.86	1.59	1.03	1.44	0.92	1.21	1
Min	0.37	0.73	0.74	0.36	0.50	0.44	0.55
Std	0.51	0.28	0.09	0.29	0.13	0.24	0.15
n	16	13	17	12	12	8	8

Parameter Location	<b>CHOLESTEROL</b>						
	AEC neonate	AEC calf	AEC cow	Ranch A calf	Ranch A cow	Ranch B calf	Ranch B cow
Age							
Mean	0.96	3.15	2.79	2.23	2.70	2.25	3.37
Max	2.09	3.97	3.43	3.44	3.64	3.20	4.57
Min	0.54	2.52	1.98	1.04	1.67	1.56	2.62
Std	0.39	0.40	0.41	0.72	0.49	0.62	0.68
n	16	13	17	12	12	8	8

Parameter Location	<b>TRIGLYCERIDE</b>						
	AEC neonate	AEC calf	AEC cow	Ranch A calf	Ranch A cow	Ranch B calf	Ranch B cow
Age							
Mean	0.39	0.58	0.21	0.46	0.17	0.34	0.29
Max	0.86	1.41	0.31	1.12	0.22	0.66	0.52
Min	0.18	0.19	0.16	0.12	0.12	0.14	0.14
Std	0.18	0.36	0.04	0.31	0.03	0.16	0.11
n	16	13	17	12	12	8	8

<sup>1</sup> Blood samples taken in 1994 from neonatal calves, older calves (12-50 days of age) and cows

<sup>2</sup> Blood samples taken in 1994

<sup>3</sup> Maximum value

<sup>4</sup> Minimum value

<sup>5</sup> Standard deviation of the mean

<sup>6</sup> Number of observations

Table 17 Summary of Clinical Pathology Data from Alberta Environmental Centre Cattle,  
Ranch A and Ranch B Cows and Calves

Parameter Location	<b>SODIUM</b>						
	AEC neonate	AEC calf	AEC cow	Ranch A <sup>1</sup> calf	Ranch A <sup>1</sup> cow	Ranch B <sup>2</sup> calf	Ranch B <sup>2</sup> cow
Age							
Mean	142	147	143	142	141	140.7	140
Max <sup>3</sup>	145	150	145	145	146	145	144
Min <sup>4</sup>	136	145	142	140	137	138	138
Std <sup>5</sup>	2.6	1.8	1.07	1.3	3	2.49	2
n <sup>6</sup>	16	13	17	12	12	8	8

Parameter Location	<b>POTASSIUM</b>						
	AEC neonate	AEC calf	AEC cow	Ranch A calf	Ranch A cow	Ranch B calf	Ranch B cow
Age							
Mean	5.2	5.3	4.3	5.5	4.0	6.0	4.2
Max	5.8	6.4	5.1	6.7	5.4	6.7	4.6
Min	4.5	4.7	3.9	5.5	3.1	5.3	3.9
Std	0.64	0.50	0.36	1.73	0.65	0.39	0.24
n	15	13	17	12	12	8	8

Parameter Location	<b>CHLORIDE</b>						
	AEC neonate	AEC calf	AEC cow	Ranch A calf	Ranch A cow	Ranch B calf	Ranch B cow
Age							
Mean	99	103	99	98	95	98.6	96.6
Max	106	105	102	102	103	101	100
Min	93	100	9.7	94	90	95	91
Std	3.3	1.7	1.45	2.54	3.75	1.76	2.9
n	16	13	17	12	12	8	8

Parameter Location	<b>IRON</b>						
	AEC neonate	AEC calf	AEC cow	Ranch A calf	Ranch A cow	Ranch B calf	Ranch B cow
Age							
Mean	15	51	27	30.4	21.8	26	24.5
Max	33	83	38	79	27	40	45
Min	2	14	18	2	18	6	18
Std	8.1	21.4	5.1	21.3	2.8	12	8.9
n	16	13	17	12	12	8	8

<sup>1</sup> Blood samples taken in 1994 from neonatal calves, older calves (12-50 days of age) and cows

<sup>2</sup> Blood samples taken in 1994

<sup>3</sup> Maximum value

<sup>4</sup> Minimum value

<sup>5</sup> Standard deviation of the mean

<sup>6</sup> Number of observations

Table 17      Summary of Clinical Pathology Data from Alberta Environmental Centre Cattle,  
Ranch A and Ranch B Cows and Calves

Parameter Location	<u>IRON BIND CAPACITY</u>						
	AEC neonate	AEC calf	AEC cow	Ranch A <sup>1</sup> calf	Ranch A <sup>1</sup> cow	Ranch B <sup>2</sup> calf	Ranch B <sup>2</sup> cow
Age							
Mean	38	60	34	52.6	29.5	60	26.6
Max <sup>3</sup>	70	76	43	72	37	72	31
Min <sup>4</sup>	16	30	19	10	19	46	15
Std <sup>5</sup>	13.2	16.3	6.6	19.8	5	9.6	5.4
n <sup>6</sup>	16	13	17	12	12	8	8

Parameter Location	<u>TOTAL IRON BINDING CAPACITY</u>						
	AEC neonate	AEC calf	AEC cow	Ranch A calf	Ranch A cow	Ranch B calf	Ranch B cow
Age							
Mean	53	111	61	83.5	51	87	51
Max	73	129	71	111	58	97	60
Min	39	89	44	69	41	75	44
Std	8.1	11	5.9	12.5	4.3	6.8	5.1
n	16	13	17	12	12	8	8

Parameter Location	<u>THYROXIN (T4) ANALYSIS AEC</u>	
	AEC neonate	AEC calf
Age		
Mean	216	107
Max	291	133
Min	143	89
Std	48	13.9
n	16	13

<sup>1</sup> Blood samples taken in 1994 from neonatal calves, older calves (12-50 days of age) and cows

<sup>2</sup> Blood samples taken in 1994

<sup>3</sup> Maximum value

<sup>4</sup> Minimum value

<sup>5</sup> Standard deviation of the mean

<sup>6</sup> Number of observations

Table 18 Summary of Serum Protein Electrophoresis (% and Raw Data) on Ranch A and Ranch B Cattle, and AEC Cattle that were Included for Comparisons

Accession Number	Animal Number	Date Collected	Collection Days	Albumin g/L	Alpha 1 g/L	Alpha 2 g/L	Beta g/L	Gamma g/L	Total Protein g/L	A\G Ratio	Site	
94.0261	21D	94.04.22	1	34.2 <sup>a</sup>	12.9	10.6	22.5	70	0.52	AEC		
94.0262	22D	94.04.07	1	46.9	1.2	13.2	14.4	4.8	45	0.88	AEC	
94.0262	22D	94.05.03	27	57.0	2.9	7.3	10.3	4.0	57	1.32	AEC	
94.0265	25D	94.04.26	<1	54.2	1.3	12.4	13.7	3.4	38	1.18	AEC	
94.0266	26D	94.04.08	<1	55.5 <sup>a</sup>	<sup>a</sup>	13.4	3.6	0.8	40	1.24	AEC	
94.0266	26D	94.05.03	25	50.6	2.4	6.9	9.3	12.6	62	1.03	AEC	
94.0268	28D	94.04.18	1	29.9	2.5	11.6	14.1	16.9	24.4	0.43	AEC	
94.0268	28D	94.05.03	18	41.5	3.0	7.5	10.5	15.7	69	0.71	AEC	
94.0269	29D	94.05.03	18	44.9	2.5	8.9	11.4	13.7	66	0.82	AEC	
94.0270	30D	94.04.20	1.5	38.0 <sup>a</sup>	<sup>a</sup>	14.2	8.0	15.0	60	0.61	AEC	
94.0270	30D	94.05.03	12	45.8	2.7	8.6	11.3	13.2	64	0.85	AEC	
94.0260	50D	94.04.20	1.5	40.2	<sup>a</sup>	16.8	7.6	12.7	62	0.67	AEC	
94.0260	50D	94.05.03	12	48.6	3.5	8.2	11.7	10.6	7.5	0.95	AEC	
94.0261	31D	94.04.20	1	30.6 <sup>a</sup>	<sup>a</sup>	13.6	10.2	29.0	76	0.44	AEC	
94.0273	33D	94.04.18	1	44.4 <sup>a</sup>	<sup>a</sup>	13.6	5.8	8.4	50	0.80	AEC	
94.0274	34D	94.04.20	1.5	38.1	1.5	13.3	14.8	10.0	13.0	0.61	AEC	
94.0274	34D	94.05.03	12	48.4	1.9	8.6	10.5	13.2	7.7	0.94	AEC	
94.0275	35D	94.04.20	1.5	27.5 <sup>a</sup>	<sup>a</sup>	13.1	7.8	32.8	74	0.38	AEC	
94.0275	35D	94.05.03	14	42.6	2.0	8.4	10.4	13.3	14.7	0.74	AEC	
94.0280	40D	94.04.29	1	34.9	1.0	13.1	14.1	9.9	15.0	0.54	AEC	
94.0281	41D	94.05.03	46	55.7	2.9	8.1	11.0	10.0	3.4	55	1.26	AEC

<sup>a</sup>One peak observed in electrophoresis, see value for Alpha 1 & 2

Table 18

Summary of Serum Protein Electrophoresis (% and Raw Data) on Ranch A and Ranch BCattle, and AEC Cattle that were Included for Comparisons (Cont'd)

Accession Number	Animal	Date Collected	Collection Age in Days	Albumin g/L	Alpha 1 g/L	Alpha 2 g/L	Beta g/L	Gamma g/L	Total Protein g/L	A\G Ratio	Site
94.0282	43D	94.04.06	<1	57.2 <sup>a</sup>	2.3 <sup>a</sup>	7.5	9.8	10.6	5.8	36	1.34
94.0282	43D	94.05.03	27	54.0	2.3	7.5	9.8	10.6	5.8	57	1.17
94.0283	44D	94.04.01	1	37.7	1.5	13.4	14.9	7.5	11.2	54	0.60
94.0283	44D	94.05.03	32	50.4	3.9	8.5	12.4	12.2	5.1	60	1.02
94.0284	46D	94.03.25	1	42.9 <sup>a</sup>	<sup>a</sup>	14.2	5.0	8.2	48	0.75	AEC
94.0284	46D	94.05.03	39	55.2	2.9	8.0	10.9	11.4	3.3	57	1.23
94.0285	53D	94.05.03	46	53.5	2.8	7.8	10.6	12.0	4.8	59	1.15
94.0328	GrD119	94.05.05	12	46.7	2.9	9.5	12.4	9.6	8.9	58	0.88
94.0329	Y158	94.05.05	13	49.7	1.8	9.0	10.8	11.1	8.7	61	0.99
94.0330	Y155	94.05.05	13	42.2	1.9	11.1	13.0	9.4	16.3	67	0.73
94.0331	Y160	94.05.05	7	48.6	2.6	10.7	13.3	7.5	2.7	46	0.95
94.0336	GrD120	94.05.05	11	39.3	2.1	9.7	11.8	15.9	16.6	73	0.65
94.0335	GrD122	94.05.05	8	46.1 <sup>a</sup>	<sup>a</sup>	9.2	9.1	13.0	58	0.85	Ranch A
94.0327	Y154	94.05.05	15	49.1 <sup>a</sup>	<sup>a</sup>	11.6	11.1	7.3	59	0.97	Ranch A
94.0338	GrD123	94.05.05	6	35.3	3.6	10.3	13.9	14.0	19.9	74	0.55
94.0332	Y156	94.05.05	13	37.5	2.4	8.4	10.8	12.3	18.1	66	0.60
94.0334	GrD118	94.05.05	6	30.2 <sup>a</sup>	<sup>a</sup>	10.7	15.1	29.4	79	0.43	Ranch A
94.0337	Y161	94.05.05	3	56.4 <sup>a</sup>	<sup>a</sup>	11.8	5.5	1.9	44	1.29	Ranch A
94.0333	GrD121	94.05.05	6	40.2 <sup>a</sup>	<sup>a</sup>	12.3	11.9	15.9	67	0.67	Ranch A
94.0319	61a	94.05.05	24	46.0 <sup>a</sup>	<sup>a</sup>	10.0	13.4	11.1	64	0.85	Ranch B
94.0320	15a	94.05.05	8	32.7 <sup>a</sup>	<sup>a</sup>	11.1	12.6	26.8	75	0.49	Ranch B

<sup>a</sup>One peak observed in electrophoresis, see value for Alpha 1 & 2

Table 18

Summary of Serum Protein Electrophoresis (% and Raw Data) on Ranch A and Ranch B Cattle, and AEC Cattle that were Included for Comparisons (Cont'd)

Accession Number	Animal Number	Date Collected	Collection Age in Days	Albumin g/L	Alpha 1 g/L	Alpha 2 g/L	Beta g/L	Gamma g/L	Total Protein g/L	A\G Ratio	Site
94.0321	89a	94.05.05	26	47.6	1.1	8.5	9.6	12.9	8.4	59	0.91
94.0322	89-1	94.05.05	26	53.9	2.5	7.8	10.3	9.5	4.6	53	1.17
94.0323	64a	94.05.05	30	53.9	3.4	8.4	11.8	11.6	4.8	61	1.17
94.0324	153a	94.05.05	5	50.5	1.9	9.8	11.7	8.9	5.7	53	1.02
94.0325	17a	94.05.05	34	53.8	2.2	7.4	9.6	11.9	6.2	60	1.16
94.0326	50a	94.05.05	26	56.0	4.7	9.0	13.7	8.8	2.6	57	1.27
94.0261	21D	94.04.22	1	34.2	a	a	18.4	15.2	32.2		AEC
94.0262	22D	94.04.07	1	46.9	2.6	29.4	32.0	10.3	10.6		AEC
94.0262	22D	94.05.03	27	57.0	5.0	12.8	17.8	18.1	7.1		AEC
94.0265	25D	94.04.26	<1	54.2	3.5	32.5	36.0	8.9	0.8		AEC
94.0266	26D	94.04.08	<1	55.5	a	a	33.5	9.0	2.1		AEC
94.0266	26D	94.05.03	25	50.6	3.8	11.1	14.9	20.3	14.2		AEC
94.0268	28D	94.04.18	1	29.9	3.2	14.6	17.8	21.4	30.8		AEC
94.0268	28D	94.05.03	18	41.5	4.3	10.9	15.2	22.8	20.6		AEC
94.0269	29D	94.05.03	18	44.9	3.8	13.5	17.3	20.7	17.1		AEC
94.0270	30D	94.04.20	1.5	38.0	a	a	23.6	13.4	25.0		AEC
94.0270	30D	94.05.03	12	45.8	4.3	13.4	17.7	20.6	16.0		AEC
94.0260	50D	94.04.20	1.5	40.2	a	a	27.1	12.3	20.4		AEC
94.0260	50D	94.05.03	12	48.6	6.0	14.1	20.1	18.3	13.0		AEC
94.0261	31D	94.04.20	1	30.6	a	a	17.9	13.4	38.1		AEC
94.0273	33D	94.04.18	1	44.4	a	a	27.1	11.7	16.8		AEC

<sup>a</sup>One peak observed in electrophoresis, see value for Alpha 1 & 2

Table 18

Summary of Serum Protein Electrophoresis (% and Raw Data) on Ranch A and Ranch BCattle, and AEC Cattle that were Included for Comparisons (Cont'd)

Accession Number	Animal Number	Date Collected	Age in Days	Collection	Albumin	Alpha 1	Alpha 2	Beta	Gamma	Total Protein	A\G Ratio	Site
				g/L	g/L	g/L	g/L	g/L	g/L	g/L	g/L	
94.0274	34D	94.04.20	1.5	38.1	2.4	21.9	24.3	16.4	21.3			AEC
94.0274	34D	94.05.03	12	48.4	3.2	14.2	17.4	21.6	12.7			AEC
94.0275	35D	94.04.20	1.5	27.5	a	a	17.6	10.6	44.3			AEC
94.0275	35D	94.05.03	14	42.6	3.0	12.6	15.6	19.9	21.9			AEC
94.0280	40D	94.04.29	1	34.9	1.7	21.9	23.6	16.5	25.0			AEC
94.0281	41D	94.05.03	46	55.7	5.3	14.7	20.0	18.2	6.2			AEC
94.0282	43D	94.04.06	<1	57.2	a	a	32.1	9.0	1.7			AEC
94.0282	43D	94.05.03	27	54.0	4.1	13.2	17.3	18.5	10.2			AEC
94.0283	44D	94.04.01	1	37.7	2.8	24.8	27.6	13.9	20.8			AEC
94.0283	44D	94.05.03	32	50.4	6.5	14.2	20.7	20.4	8.4			AEC
94.0284	46D	94.03.25	1	42.9	a	a	29.6	10.4	17.1			AEC
94.0284	46D	94.05.03	39	55.2	5.1	14.0	19.1	20.0	5.8			AEC
94.0285	53D	94.05.03	46	53.5	4.7	13.2	17.9	20.4	8.1			AEC
94.0328	GrD119	94.05.05	12	46.7	4.9	16.4	21.3	16.6	15.4			Ranch A
94.0329	Y158	94.05.05	13	49.7	3.0	14.8	17.8	18.3	14.3			Ranch A
94.0330	Y155	94.05.05	13	42.2	2.9	16.5	19.4	14.0	24.4			Ranch A
94.0331	Y160	94.05.05	7	48.6	5.7	23.3	29.0	16.4	6.0			Ranch A
94.0336	GrD120	94.05.05	11	39.3	2.8	13.3	16.1	21.8	22.8			Ranch A
94.0335	GrD122	94.05.05	8	46.1	a	a	15.9	15.7	22.4			Ranch A
94.0327	Y154	94.05.05	15	49.1	a	a	19.6	18.8	12.5			Ranch A
94.0338	GrD123	94.05.05	6	35.3	4.8	13.9	18.7	19.0	27.0			Ranch A

<sup>a</sup>One peak observed in electrophoresis, see value for Alpha 1 & 2

Table 18 Summary of Serum Protein Electrophoresis (% and Raw Data) on Ranch A and Ranch B Cattle, and AEC Cattle that were Included for Comparisons (Cont'd)

Accession Number	Animal Number	Date Collected	Collection Date	Albumin	Alpha 1	Alpha 2	Alpha 1 & 2	Beta	Gamma	Total Protein	A\G Ratio	Site
				g/L	g/L	g/L	g/L	g/L	g/L	g/L	g/L	
94.0332	Y156	94.05.05	13	37.5	3.7	12.8	16.5	18.7	27.4			Ranch A
94.0334	GrD118	94.05.05	6	30.2	a	a	13.5	19.1	37.2			Ranch A
94.0337	Y161	94.05.05	3	56.4	a	a	26.8	12.4	4.4			Ranch A
94.0333	GrD121	94.05.05	6	40.2	a	a	18.3	17.8	23.7			Ranch A
94.0319	61a	94.05.05	24	46.0	a	a	15.7	21.0	17.4			Ranch B
94.0320	15a	94.05.05	8	32.7	a	a	14.7	16.8	35.8			Ranch B
94.0321	89a	94.05.05	26	47.6	1.8	14.5	16.3	21.9	14.2			Ranch B
94.0322	89-1	94.05.05	26	53.9	4.7	14.7	19.4	18.0	8.7			Ranch B
94.0323	64a	94.05.05	30	53.9	5.5	13.7	19.2	19.1	7.8			Ranch B
94.0324	153a	94.05.05	5	50.5	3.5	18.4	21.9	16.9	10.7			Ranch B
94.0325	17a	94.05.05	34	53.8	3.7	12.3	16.0	19.8	10.4			Ranch B
94.0326	50a	94.05.05	26	56.0	8.2	15.7	23.9	15.4	4.6			Ranch B
92.0261	1Z	94.05.03		46.9	1.9	13.4	15.3	14.6	23.2			AEC
92.0262	2Z	94.05.03		46.2	3.3	14.0	17.3	15.4	21.0			AEC
92.0265	5Z	94.05.03		49.3	3.2	12.3	15.5	14.1	21.1			AEC
92.0266	6Z	94.05.03		46.9	3.2	11.4	14.6	10.7	27.8			AEC
92.0268	8Z	94.05.03		49.5	1.6	13.2	14.8	14.5	21.2			AEC
92.0269	9Z	94.05.03		47.4	0.6	12.6	13.2	15.6	23.7			AEC
92.0270	10Z	94.05.03		47.8	a	a	16.4	15.0	20.7			AEC
92.0271	11Z	94.05.03		49.8	3.6	12.5	16.1	17.0	17.1			AEC
92.0273	13Z	94.05.03		42.7	5.0	10.6	15.6	9.9	31.9			AEC

<sup>a</sup>One peak observed in electrophoresis, see value for Alpha 1 & 2

Table 18

Summary of Serum Protein Electrophoresis (% and Raw Data) on Ranch A and Ranch B Cattle, and AEC Cattle that were Included for Comparisons (Cont'd)

Accession Number	Animal Number	Date Collected	Collection Days	Albumin g/L	Alpha 1 g/L	Alpha 2 g/L	Beta g/L	Gamma g/L	Total Protein g/L	A\G Ratio	Site
92.0274	14Z	94.05.03		55.0	a	a	13.3	13.3	18.5		AEC
92.0275	15Z	94.05.03		49.9	a	a	14.5	11.9	23.7		AEC
92.0280	20B	94.05.03		54.6	5.7	10.8	16.5	14.2	22.5		AEC
92.0281	21B	94.05.03		52.6	3.3	15.0	18.3	14.8	14.3		AEC
92.0283	23B	94.04.26		48.3	5.6	11.2	16.8	10.2	24.7		AEC
92.0283	23B	94.05.03		54.0	3.2	13.1	16.3	15.4	14.2		AEC
92.0284	24B	94.05.03		54.2	3.0	13.5	16.5	13.8	15.4		AEC
92.0286	26B	94.04.26		49.0	4.1	10.3	14.4	9.6	27.0		AEC
92.0286	26B	94.05.03		47.2	4.1	10.4	14.5	10.7	27.6		AEC
92.0293	33B	94.05.03		62.3	a	a	13.8	12.0	11.9		AEC
94.0339	Gr122	94.05.05		44.3	1.9	12.4	14.3	8.8	32.5		Ranch A
94.0340	Gr101	94.05.05		45.7	5.5	10.5	16.0	6.0	32.3		Ranch A
94.0341	B6	94.05.05		45.0	3.2	12.2	15.4	9.6	30.0		Ranch A
94.0342	Gr211	94.05.05		37.7	a	a	15.6	12.8	33.9		Ranch A
94.0343	Gr45	94.05.05		46.4	3.1	12.0	15.1	11.0	27.5		Ranch A
94.0344	Gr49	94.05.05		40.8	1.9	12.8	14.7	10.7	33.8		Ranch A
94.0345	Gr162	94.05.05		43.3	3.4	10.6	14.0	8.1	34.6		Ranch A
94.0346	Gr36	94.05.05		48.5	5.9	11.3	17.2	10.5	23.8		Ranch A
94.0050	Gr106	94.05.05		45.7	5.6	10.9	16.5	11.1	26.6		Ranch A
93.0607	Gr18	94.05.05		48.3	2.8	12.2	15.0	10.3	26.3		Ranch A
94.0295	Y103	94.05.05		36.7	1.3	14.8	16.1	11.4	35.8		Ranch A

<sup>a</sup>One peak observed in electrophoresis, see value for Alpha 1 & 2

Table 18

Summary of Serum Protein Electrophoresis (% and Raw Data) on Ranch A and Ranch B Cattle, and AEC Cattle that were Included for Comparisons (Cont'd)

Accession Number	Animal Number	Date Collected	Collection Age in Days	Albumin g/L	Alpha 1 g/L	Alpha 2 g/L	Beta g/L	Gamma g/L	Total Protein g/L	A\G Ratio	Site
91.1075	Gr66	94.05.05		46.8	5.7	10.8	16.5	14.2	22.5		Ranch A
94.0312	BT61B1	94.05.05		39.4	6.2	11.4	17.6	14.2	28.7		Ranch B
94.0313	BT15	94.05.05		46.0	2.4	15.9	18.3	14.3	21.4		Ranch B
94.0314	BT89	94.05.05		38.0	3.8	12.3	16.1	21.7	24.2		Ranch B
94.0315	BT64	94.05.05		42.9	7.5	12.0	19.5	11.8	25.9		Ranch B
94.0316	BT153	94.05.05		41.3	1.7	12.0	13.7	18.9	26.1		Ranch B
94.0317	BT17	94.05.05		52.1	1.6	12.6	14.2	13.4	20.3		Ranch B
94.0318	BT50B1	94.05.05		39.5	3.4	10.9	14.3	13.2	33.0		Ranch B
92.0261	1Z	94.05.03		46.9	1.4	10.1	11.5	10.9	17.4	75	0.88
92.0262	2Z	94.05.03		46.2	2.4	10.1	12.5	11.1	15.1	72	0.86
92.0265	5Z	94.05.03		49.3	2.5	9.3	11.8	10.7	16.1	76	0.97
92.0266	6Z	94.05.03		46.9	2.5	8.9	11.4	8.4	21.7	78	0.88
92.0268	8Z	94.05.03		49.5	1.1	9.5	10.6	10.4	15.3	72	0.98
92.0269	9Z	94.05.03		47.4	0.5	9.8	10.3	12.2	18.5	78	0.90
92.0270	10Z	94.05.03		47.8	a	a	11.7	10.7	14.7	71	0.91
92.0271	11Z	94.05.03		49.8	2.5	8.5	11.0	11.5	11.7	68	0.99
92.0273	13Z	94.05.03		42.7	3.8	8.1	11.9	7.6	24.5	77	0.75
92.0274	14Z	94.05.03		55.0	a	a	9.5	9.6	13.3	72	1.22
92.0275	15Z	94.05.03		49.9	a	a	10.9	9.0	17.8	75	0.99
92.0280	20B	94.05.03		38.7	4.2	8.0	12.2	10.5	9.8	71	1.20
92.0281	21B	94.05.03		38.4	2.4	11.0	13.4	10.8	10.4	73	1.11

<sup>a</sup>One peak observed in electrophoresis, see value for Alpha 1 & 2

Table 18

Summary of Serum Protein Electrophoresis (% and Raw Data) on Ranch A and Ranch B Cattle, and AEC Cattle that were Included for Comparisons (Cont'd)

Accession Number	Animal Number	Date Collected	Collection Days	Albumin g/L	Alpha 1 g/L	Alpha 2 g/L	Beta g/L	Gamma g/L	Total Protein g/L	A\G Ratio	Site
92.0283	23B	94.04.26	32.9	3.8	7.6	11.4	7.0	16.8	68	0.94	AEC
92.0283	23B	94.05.03	37.3	2.2	9.1	11.3	10.6	9.8	69	1.17	AEC
92.0284	24B	94.05.03	38.0	2.1	9.5	11.6	9.7	10.8	70	1.19	AEC
92.0286	26B	94.04.26	37.7	3.2	7.9	11.1	7.4	20.8	77	0.96	AEC
92.0286	26B	94.05.03	36.4	3.2	8.0	11.2	8.2	21.2	77	0.90	AEC
92.0293	33B	94.05.03	44.9	<sup>a</sup>	9.9	8.6	8.6	72	72	1.65	AEC
94.0339	Gr122	94.05.05	44.3	1.4	9.2	10.6	6.5	24.1	74	0.80	Ranch A
94.0340	Gr101	94.05.05	45.7	4.1	7.8	11.9	4.4	23.9	74	0.84	Ranch A
94.0341	B6	94.05.05	45.0	2.5	9.2	11.7	7.3	22.8	76	0.82	Ranch A
94.0342	Gr211	94.05.05	37.7	<sup>a</sup>	<sup>a</sup>	11.5	9.5	25.1	74	0.61	Ranch A
94.0343	Gr45	94.05.05	46.4	2.3	8.6	10.9	7.9	19.8	72	0.87	Ranch A
94.0344	Gr49	94.05.05	40.8	1.3	9.1	10.4	7.6	24.0	71	0.69	Ranch A
94.0345	Gr162	94.05.05	43.3	2.7	8.3	11.0	6.3	27.0	78	0.76	Ranch A
94.0346	Gr36	94.05.05	48.5	4.1	7.8	11.9	7.2	16.4	69	0.94	Ranch A
94.0050	Gr106	94.05.05	45.7	3.8	7.3	11.1	7.4	17.9	67	0.84	Ranch A
93.0607	Gr18	94.05.05	48.3	2.0	8.7	10.7	7.3	18.7	71	0.94	Ranch A
94.0295	Y103	94.05.05	36.7	1.0	11.6	12.6	8.9	27.9	78	0.58	Ranch A
91.1075	Gr66	94.05.05	46.8	4.2	8.0	12.2	10.5	16.7	74	0.88	Ranch A
94.0312	BT61B1	94.05.05	39.4	4.9	8.9	13.8	11.1	22.4	78	0.65	Ranch B
94.0313	BT15	94.05.05	46.0	1.8	12.1	13.9	10.9	16.2	76	0.85	Ranch B
94.0314	BT89	94.05.05	38.0	2.9	9.5	12.4	16.7	18.6	77	0.61	Ranch B

<sup>a</sup>One peak observed in electrophoresis, see value for Alpha 1 & 2

Table 18

Summary of Serum Protein Electrophoresis (% and Raw Data) on Ranch A and Ranch B Cattle, and AEC Cattle that were Included for Comparisons (Cont'd)

Accession Number	Animal Number	Date Collected	Collection Age in Days	Albumin g/L	Alpha 1 g/L	Alpha 2 g/L	Beta g/L	Gamma g/L	Total Protein g/L	A\G Ratio g/L	Site
94.0315	BT64	94.05.05		42.9	5.3	8.5	13.8	8.4	18.4	71	0.75
94.0316	BT153	94.05.05		41.3	1.3	9.3	10.6	14.6	20.1	77	0.70
94.0317	BT17	94.05.05		52.1	1.2	9.3	10.5	9.9	15.0	74	1.09
94.0318	BT50B1	94.05.05		39.5	2.9	9.3	12.2	11.2	28.0	85	0.65

<sup>a</sup>One peak observed in electrophoresis, see value for Alpha 1 & 2

Figure 4  
Linear Regression Plot of Gamma-globulin Concentrations (g/L) Versus Age of the Calves (in Days) from  
the AEC, Ranch A and Ranch B Herds

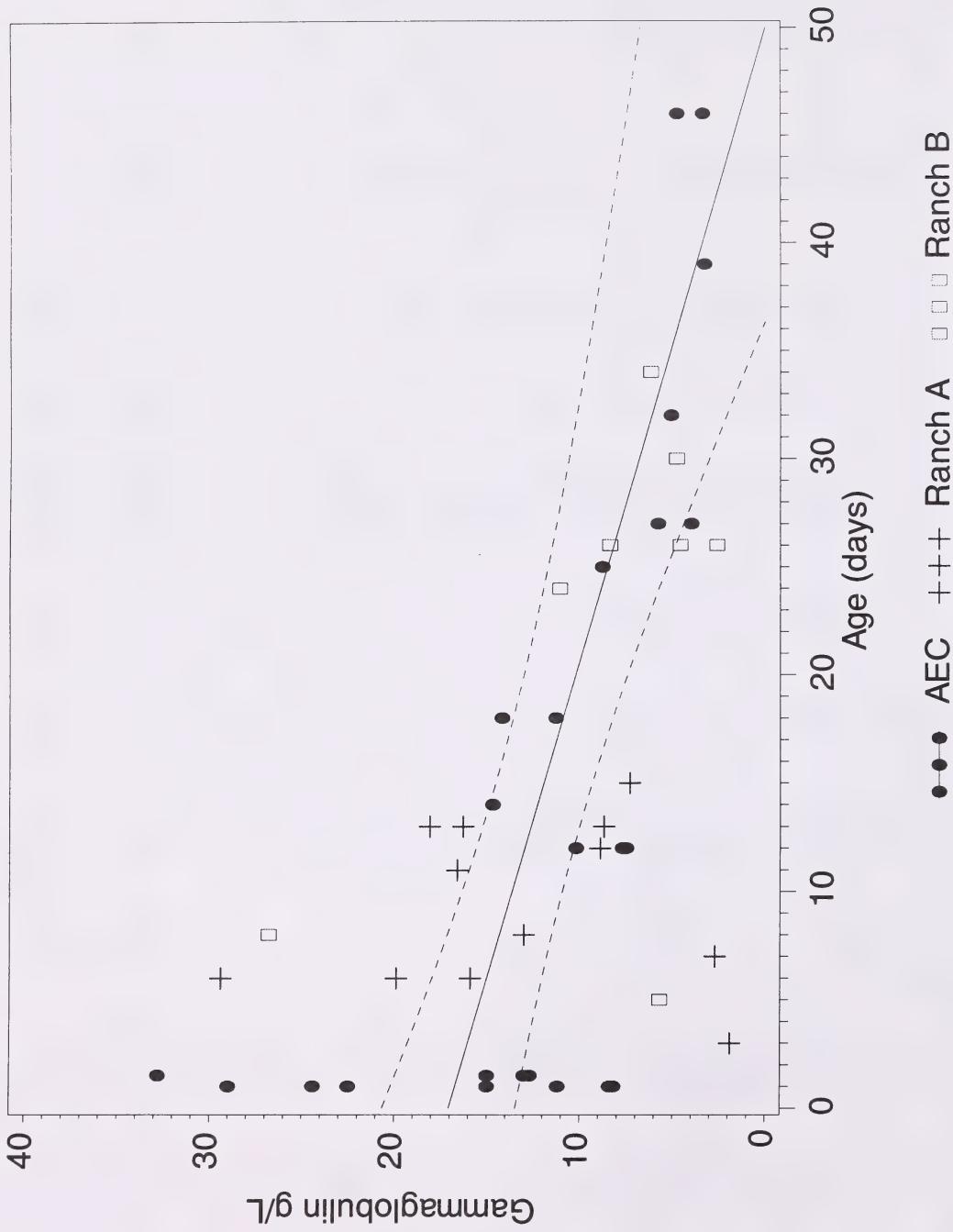
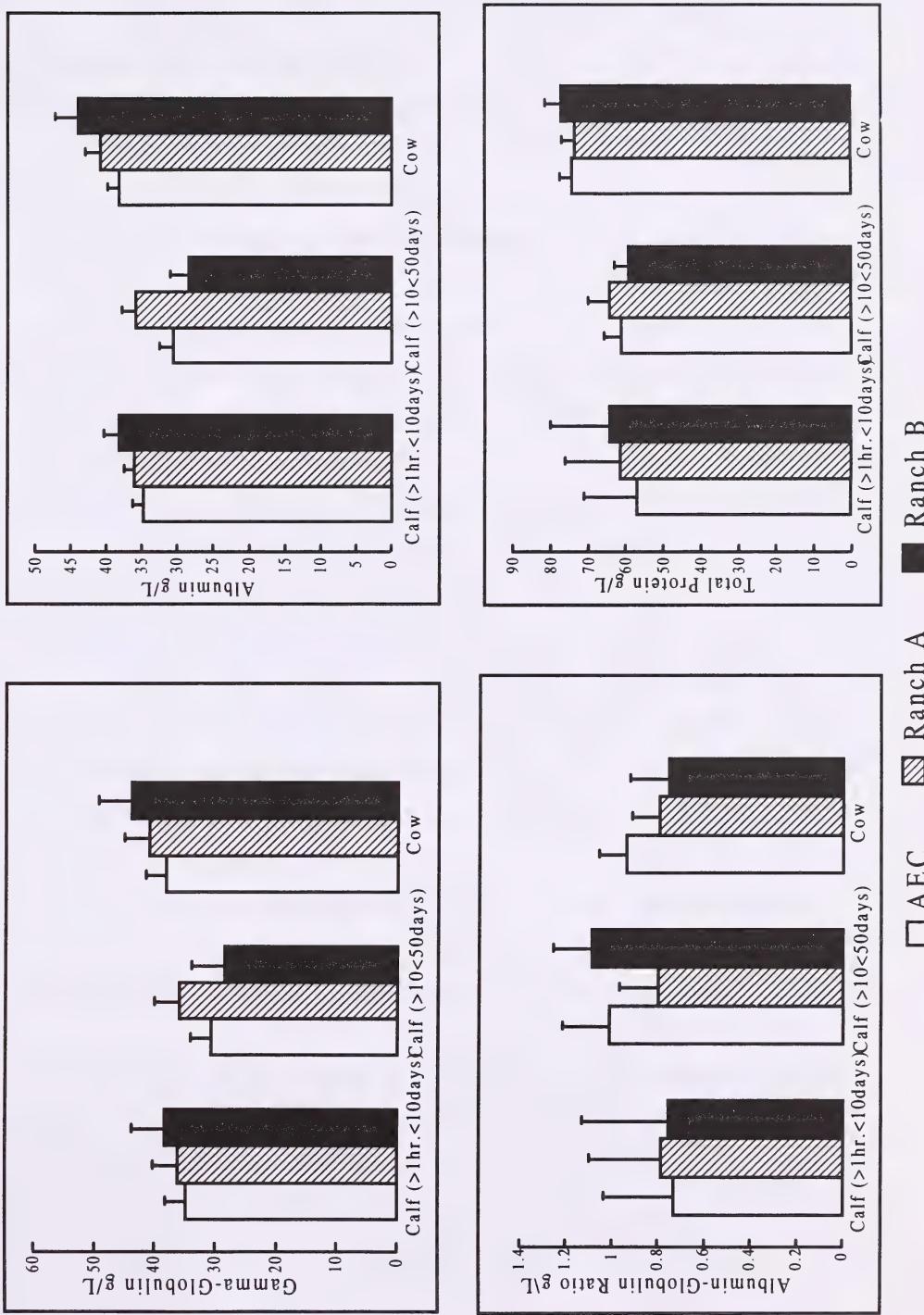


Figure 5 Summary of Ranch A (n = 12), Ranch B (n = 8, and AEC (n = 12) Clinical Pathology Data (Mean and Standard Deviation) of Young Calves and Cows



The field team walked the cattle pastures, and also viewed the reclamation area along the Red Deer River where the pipeline leak occurred.

*May 4-5. Field investigation of Ranch B.* The ranch owners reported that a heifer calf (tag No. 170 born on March 3 to a six year-old cow) had died. The calf had pale mucous membranes, was not eating and listless on May 1, and had been treated with antibiotics and electrolytes. The calf died on May 4 reportedly with froth coming from the mouth. The calf (ID No. 940287) was necropsied about 18 hours post death (Appendix B). The calf weighed about 102 kg, and had a normal amount of fat with no evidence of diarrhea. The lungs had a bilateral lobular redness affecting all of the lung lobes, and scattered area of consolidation (2.5 to 5 cm affected in the pattern). The abomasum contained a trichobezoar about 3 to 4 cm in diameter, with no visual evidence of wall thickening or erosions. The kidneys had a bilateral pattern of scattered white, round (5 mm in diameter) foci on the surface and in the kidney tissue. The liver Se, 1.9 µg/g, and liver Cu, 354 µg/g, concentrations would be considered adequate (Puls, 1990).

The most significant histopathology lesion was a necrotizing viral tracheitis and bronchitis, intranuclear viral inclusions consistent with bovine herpesvirus-1 (IBR) were present in the bronchial mucosa (Stair and Kosanke, 1997). Additional findings included a secondary mycotic infection, lymphoid hypoplasia, thymic lymphoid and bone marrow atrophy, and a necrotizing viral enterocolitis. The histopathology diagnosis of calf No. 940287 follows:

- (1) Hepatocellular centrilobular coagulative necrosis
- (2) Multifocal renal cortical necrosis and fibrosis; chronic infarcts
- (3) Pulmonary capillary leakage characterized by edema and fibrin deposits within the alveolar sacs
- (4) Necrotizing viral and mycotic bronchitis
- (5) Thymic lymphoid atrophy
- (6) Necrotizing viral tracheitis with submucosal gland hyperplasia
- (7) Necrotizing viral enterocolitis
- (8) Lymphoid hypoplasia
- (9) Bone marrow atrophy.

Another calf, born on March 5 to cow No. 23B (a four year-old) died on April 27. The ranch owner reported that he had observed that the calf was lethargic or slow at noon, and at 13:30 he found the calf dead. A local veterinarian necropsied the animal and reported that the calf had an

occluded abomasum at the pyloric opening. The ranch owner took tissue samples from the calf (ID No. 940279) in buffered formalin and requested histopathology. The histopathology lesions in the tissues submitted were multifocal hepatic necrosis and ruminal ulcers (Stair and Kosanke, 1997). The histopathology diagnosis for calf No. 940279 follows:

- (1) Multifocal hepatocellular coagulative necrosis
- (2) Multifocal ruminal ulcers.

The owners of Ranch B provided the field team with a summary of the herd in 1994. To date, in 1994 the herd consisted of the following: 37 two year-olds, one was non-pregnant and one had lost a calf; 24 three year-olds, sold 5 cows (3 open cows, 1 cow dead, culled 1 who lost a calf); 30 four-year olds, sold 4 cows (2 late calvers, 1 poor milker, 1 hurt); 15 five year-olds, sold 4 cows (1 open, 1 late calver, 1 behavior); 30 six year-olds, sold 4 or 5 to date; 14 seven year-olds remaining out of 31 cows. Two cows had clinical signs of respiratory problems, cow No. 61 had nasal discharge and cow No. 98 had raspy respiration.

At Ranch B, we took blood samples for clinical pathology, trace nutrient analyses, and immunoglobulin determinations from eight cows and eight calves, one cow (tag No. 170) had lost her calf (ID No. 940287) the previous day, and one cow (tag No. 89) had twin calves.

The serum vitamin E (alpha tocopherol) concentrations determined in the cows and calves are listed in Table 19. Generally, serum vitamin E concentrations in cows less than 3.0 mg/L would be considered marginal (Puls, 1990), and concentrations less than 1.0 mg/L can be associated with nutritional myopathies (McMurray and Rice, 1982). Serum vitamin E concentrations in "infant" calves of 10 to 29 days-of-age would have normal values of 0.5 to 1.0 mg/L, and "juvenile" calves would have normal values of 0.75 to 1.0 mg/L (Puls, 1994). Calf No. 940320 had a low vitamin E concentration of 0.4 mg/L. The owner of Ranch B reported he routinely injected the calves at birth with a vitamin E and selenium supplement. The data is summarized in a bar chart with the mean and standard deviation (SD) depicted for cows and calves (Figure 6).

The hematology and serum chemistry data from the cows and calves is listed in Appendix D. A summary of some of the clinical pathology parameters is provided in Table 17. Figure 5

Table 19 Description of Animals Bled on May 5 on Ranch B

AEC No.	Animal No.	Sex	Age/Date of Birth	DamNo.	Serum Vit. E. (mg/L)
940311	BT170	F		-cow	2.5
940312	BT61blue	F	2 yr	-cow	2.9
940313	BT15	F	4 yr	-cow	3.2
940314	BT89	F	14 yr	-cow	2.1
940315	BT64	F	9 yr	-cow	2.2
940316	BT153	F	6 yr	-cow	2.4
940317	BT17	F	4 yr	-cow	2.0
940318	BT50blue	F	3 yr	-cow	1.8
940319	61a*	F	94.04.11	BT61	
940320	15a <sup>No.</sup>	M	94.04.27	BT15	0.4
940321	89a	F	94.04.09	BT89	0.7
940322	89-1	F	94.04.09	BT89	1.1
940323	64a	F	94.04.05	BT64	
940324	153a	F	94.04.30	BT153	0.7
940325	17a	F	94.04.02	BT17	0.9
940326	50a	M	94.04.09	BT50	0.6

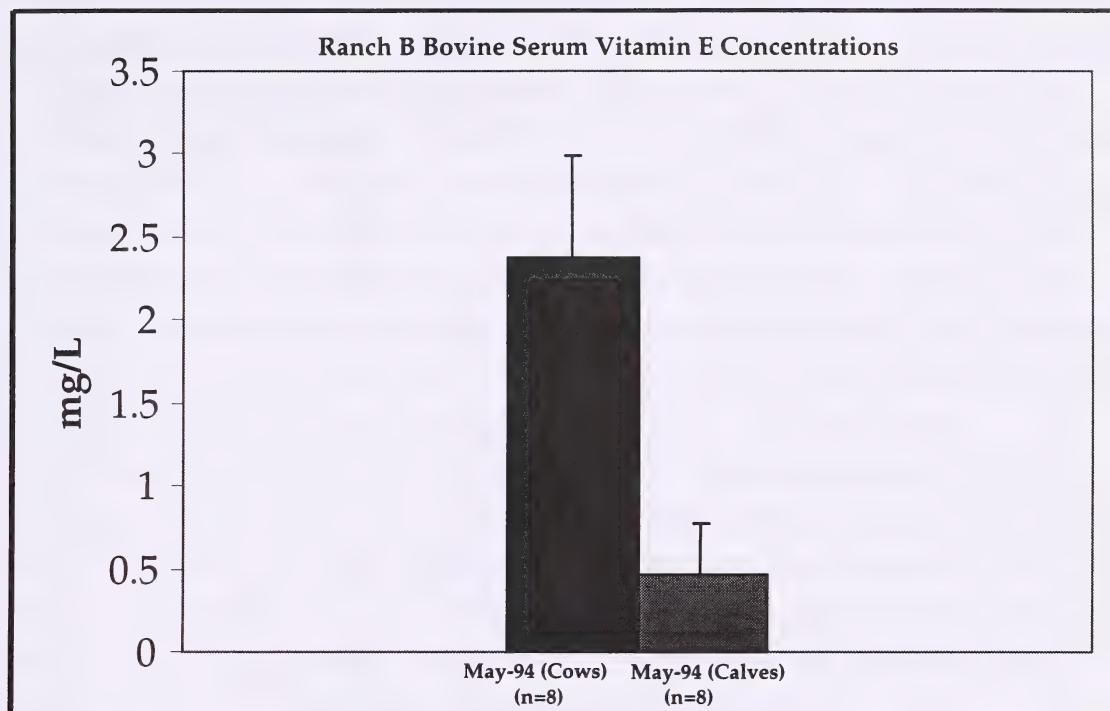
\* The calf appeared to have an umbilical infection

# The calf had a diarrhea

presents in bar chart the mean and SD of serum globulin, albumin, albumin-globulin ratio, and total protein for cows and calves from Ranch B, data from AEC cattle is included for comparison. Table 18 provides a summary of the serum protein electrophoresis data on the cows and calves bled on May 5. Many of the calves were slightly older, 25 days old or more and the serum gammaglobulin concentrations reflected the normal half-life of this protein in serum (Figure 4). One calf (ID No. 940324) who was six day-old was considered to have a low gamma globulin concentration of 5.7 g/L.

*May 16. Field trips to Ranches A and B.* The field team consisted of M. Mostrom and a veterinarian from the United States. We walked through the cattle in pastures adjacent to the James River. A nearby battery was flaring and the odor of hydrogen sulfide was very strong in

Figure 6 Serum Vitamin E Concentrations (Mean  $\pm$  SD) in Ranch B Animals



the valley. We noted a Charolais bull was in poor body condition and had a black tinge to the haircoat. The bull had lost weight when compared to his appearance in mid-April. The ranch owner stated that the bull had been in the pasture adjacent to the pipeline leak in January. A cow (No. Y62) was thin and had a stumbling gait; the Charolais cow (No. G95) appeared normal. The cow with mastitis in both rear quarters was thin. A cow (ear tag No. G142) appeared to have ruptured abdominal muscles on the left side.

*May 16. Ranch B.* We walked through the cows and calves. The Red Angus bull (tag No. 22B) continued to lose weight, had exercise intolerance, and a jugular pulse. The prognosis was poor for recovery and a recommendation was made to the owner to euthanize the bull.

*May 22.* The owner of Ranch A telephoned and reported that the cows in the pasture east of the house were walking away from their calves as if to wean them and showed a decrease in udder size.

*May 23. Field trip to Ranch B.* M. Mostrom viewed the cattle. The Red Angus bull (tag No. 22B) weighed approximately 420 kg, had a pronounced jugular pulse and a poor appetite. Another Red Angus bull had a swollen sheath back to the scrotum; the bull had been placed with cows to breed and probably had a breeding injury to the penis. A heifer (tag No. 174) had a noticeably swollen right face. The ranch owner reported that a bull calf (tag No. 174) and born on March 10, died on May 22. The ranch owner took tissue samples for histopathology from the calf (ID No. 940347). The histopathology lesions included kidney infarcts and toxic tubular nephrosis, necrotizing and hemorrhagic bronchopneumonia, splenic lymphoid follicular hypoplasia, necrotizing ileitis and depletion of lymphoid nodules of Peyer's patches (Stair and Kosanke, 1997). The etiology of the lesion could not be determined from the tissues. The histopathology diagnosis for calf No. 940367 follows:

- (1) Multiple small renal cortical infarcts
- (2) Toxic tubular nephrosis
- (3) Splenic lymphoid follicular hypoplasia
- (4) Pulmonary dystrophic mineralization of vessels
- (5) Pulmonary congestion
- (6) Acute multifocal necrotizing and hemorrhagic bronchopneumonia
- (7) Acute hemorrhagic lymphadenitis with lymphoid hypoplasia
- (8) Septic and necrotizing laryngitis with septic thromboses
- (9) Marked acute necrotizing ileitis
- (10) Marked depletion of lymphoid nodules of Peyer's patches.

Later, the ranch owner reported that a heifer calf (tag No. 160) and born on February 8 died on May 24.

*May 30-31. Field investigation to Ranch A.* The field team, consisting of M. Mostrom and C. Campbell, reviewed the calf records to date. The owner stated that he had found one dead calf the previous week, the calf apparently had been scavenged.

*May 31. Field investigation to Ranch B.* The field team reviewed cattle records. The ranch owners reported that heifers sold in December to a buyer in southern Alberta and a buyer about 40 km northwest of the ranch visually appeared in much better condition as compared with the 25 heifers kept back on the ranch.

As a follow up to the November 1993 sampling of surface water adjacent to cattle pasture on Ranch B, in conjunction with Pollution Control Division, Alberta Environment, we sampled the creek water again (Mostrom, 1994e). Adjacent to the lease site, the surface water had a hydrocarbon concentration of 0.6 mg/L, which was just above the limits of detection. We also observed the heifer No. 174 who was thin and losing body condition.

The Red Angus bull, tag No. 22B or ID No. 940278, was examined. The bull weighed about 440 kg, was carrying the testicles against the abdominal wall and had a scrotal circumference of 32 cm. Loose manure was observed on the tail and perineum. The animal was bled for clinical pathology and trace mineral analyses, and then euthanized with barbiturates. Briefly, the bull had a low RBC and hemoglobin concentration (Appendix D). The activity of LDH and GGT were elevated. The glucose, creatinine, albumin, Ca, and Na concentrations were low. The serum BUN, 17 mmol/L is elevated beyond the normal range.

The gross necropsy revealed that the bull had little evidence of body fat (Appendix B). The abomasum had several areas of edema and hemorrhage near the pyloric sphincter. The lungs had a lobular pattern of redness, especially the ventral portion of the lobes. The heart weighed 2.6 kg and had vegetative endocarditis of the right atrioventricular valve. Tissue was submitted for microbial culture. The lung had a few colonies of *Staphylococcus aureus* and many colonies of *Actinomyces pyogenes*. *Hemophilus somnus* was cultured from the heart tissue. Trace nutrient analyses included blood and tissue evaluations. The liver Se concentration of 1.0 µg/g would be considered marginal to adequate. The liver Cu, 227 µg/g, and liver Fe, 217 µg/g, concentrations would be considered adequate (Puls, 1990). The kidney Cd concentration of 1.5 µg/g would be considered a normal background value (Puls, 1990). The plasma zinc, 2.0 µg/mL, concentration is high (Puls, 1990), but the plasma vitamin E concentration was less than the detection limit.

The histopathology lesions were vegetative valvular endocarditis on the right side that apparently led to the pulmonary and hepatic lesions (Stair and Kosanke, 1997). The histopathology diagnosis on bull No. 940278 follows:

- (1) Hepatic congestion with centrilobular hemorrhagic necrosis and fibrosis
- (2) Focal acute purulent pneumonia with thromboembolism
- (3) Vegetative valvular endocarditis involving the tricuspid valve.

*June 5. Telephone conversation with Ranch A owner.* The Ranch A owner reported that on June 3, he smelled petroleum or chemical odors that were very irritating to the upper respiratory

tract; the odor was not a hydrogen sulfide smell. The owner had five baby ducks in the house, and the next morning four of five baby ducks were dead. On June 5 he noted another calf (ear tag No. Y55) born February 16 to cow No. 201, was down walking on the front knees and was very aggressive towards humans when approached. Another calf (untagged calf) died on June 4; the calf was approximately five weeks old. The ranch owner thought that about 90% of his calf crop had poor hair coats and looked "scruffy". Approximately the same time, he said that he observed a lot of small airplane traffic that appeared to be following pipelines.

*June 21. Ranch B.* R. Coppock and M. Mostrom interviewed the owners of Ranch B. The ranch owners reviewed some of the feeding and management of the cattle. The owner had been providing a molasses lick to the cows and yearlings for the past three calvings. The cows were always supplemented with oats (rolled). The owner mixed some molasses liquid into about 150 pounds or 125 bushels of grain and fed about 3 to 5 pounds/head/day beginning in mid-to-late December, or about one-half month prior to calving. The cows received grain through the calving period. In 1994, the ranch owners reported that they fed up to 8 to 10 pounds/head/day of rolled oats.

This spring the ranch owners observed that the cows and calves at the home place had not shed their winter hair coats well, nor did the calves have the level of activity (running and playing) normally observed in the herd. Some of the calf birth weights were about 9 kg less than the expected normal birth weight (50 pounds versus 70 to 80 pounds).

*June 22. Ranch A.* The ranch owner reported to M. Mostrom that a petroleum facility must have malfunctioned. He noted a large flare, fire, and noise at about 03:00 on June 22. A fine oil mist covered the house, vehicles, tree leaves, and most outside areas. On June 22, M. Mostrom noted that the film on the windows and vehicles did feel smooth, lubricant like. The ranch owner gave M. Mostrom tissue samples for histopathology evaluation from a calf born to cow No. Y63, born on May 13 and died on May 25. The samples were taken by the ranch owner and placed in buffered formalin. The cause of death could not be determined from the submitted tissues; the histopathology diagnosis from calf No. 940370 follows:

- (1) Perirenal hemorrhage and edema
- (2) Splenic atrophy (red pulp decreased) and lymphoid follicular hypoplasia.

On June 22, M. Mostrom walked cattle pasture and viewed the herd immediately north, northeast of the house. In one cattle pasture, M. Mostrom noted straw bales and stakes in the

pasture with absorbent pads in a culvert east of the 13-2 lease. Over the past five years, several incidents involving the lease and potential contamination of the cattle pasture had been documented (Mostrom, 1994d).

*June 22.* A meeting was held to review the livestock monitoring since the pipeline break, and to achieve a process to put the results together for release to the community regarding the effect on livestock in the area. The participants were representatives and consultants for the petroleum company, and representatives from Alberta Environment<sup>1</sup>, Alberta Energy and Utilities Board (AEUB) and AEC (Mostrom, 1994f).

*August 10.* The owner of Ranch A called to report that he had found a dead cow (No. 58) with her head stretched out.

*August 11.* The owner of Ranch B called to report that an obnoxious chemical-like odor came through the cattle yard earlier in the evening. Later in the evening he noticed that his dogs were very lethargic and falling asleep. The next day, the ranch owner phoned to report that the pup and middle-aged dog were unconscious and the older dog was semi-comatose. The last animal killed with a barbiturate and necropsied (No. 940278 on May 31) had been buried deep and the dogs had not disturbed the site. No other animals were observed with these clinical signs. On August 13, the dogs were starting to wake up.

*August 22.* The owner of Ranch A called to report that he had found another cow, a Hereford, dead with blood coming from the nose.

Several veterinary consultants for the petroleum company came to AEC to discuss the livestock investigation and the different approaches to evaluate maladies in animal health and productivity (Mostrom, 1994g).

*August 23-24. Field investigation to Ranch A.* The field team of M. Mostrom and C. Campbell reviewed cattle records and walked through the cows and calves on the various leases. Most of the cows and calves were in good body condition, except No. G3. The Charolais-cross calf (ear tag No. Y55) which had gone down on its knees to walk in the summer, was walking with a stiff front-legged gait. The knee joints were enlarged. This calf also charged people, vehicles, and dogs.

The owner reported a pipeline blowout in the pasture west of his place. The pipeline blew out in the early morning and a large hole was excavated to expose and repair the lines; three lines were together. Photographs were taken by the field team.

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<sup>1</sup> Now known as Alberta Environment Protection

*September 3.* On the holiday weekend, M. Mostrom went down to Ranch A to verify cattle data. While at the ranch house, a call came (at 13:20) to evacuate the house because immediately north of the cattle yard a blowout preventer had failed and was releasing sour gas and crude oil. The ranch owner and his wife decided to stay and continue their work inside the house and not be disturbed by industrial activities. About 15 minutes later, the ranch owner and M. Mostrom drove to the lease site and observed clean-up operations. Crude oil had sprayed to the south over trees and some hay bales, crude oil had collected on the ground and drained to the north, northeast along the access road. The owner had cattle pastured in the area of the lease site that he had to move to prevent any access to contaminants. While moving the cattle, M. Mostrom observed cow No. Y62 was stiff and lame on the right rear leg and front legs.

*September 12.* On September 12, representatives of AEC met with a legal representative from the government to discuss the 1994 field investigations and confidentiality (Mostrom, 1994h).

*October 12-14.* On October 14, consultants for the petroleum company and Alberta Agriculture representatives met with representatives of AEC to discuss the "wrap up" of the field investigations in 1994, particularly the importance of necropsies and histopathology to diagnostic interpretations of AEC work (Penney, 1994). On October 12, the field team of M. Mostrom and C. Campbell went to Ranch A to obtain individual weights on some of the calves prior to weaning and selling the calves. Some of the cows and bulls were also weighed and six cows were bled. The serum was analyzed for vitamin E status. The raw data is presented in Table 20, and is depicted in Figure 3. The high vitamin E concentrations in the fall probably represent dietary vitamin E intake from the green pastures.

*October 22-25. Field investigation to Ranches A and B.* The field team of M. Mostrom and C. Campbell weighed the cows and calves on Ranch B and observed the weighing of the larger heifer and steer calves at weaning and shipment to the feedlot.

The field team viewed the cattle at Ranch B, and walked through the cattle pasture and fields.

Table 20 Serum Vitamin E Concentrations (mg/L) in Ranch A Cows (94.10.12)

AEC No.	Serum Vitamin E (mg/L)	AEC No.	Serum Vitamin E (mg/L)
930596 (No. G4)	8.2	900397 (No. G12)	7.2
900567 (No. G10)	6.9	940408 (No. G181)	8.9
900569 (No. G11)	6.2	940409 (No. G205)	6.8

*November 26.* M. Mostrom went to Ranch A to acquire cattle data. Some of the cows to be culled from the herd included: No. Y62 (continued to stagger), No. G95, No. G83, No. Bk38, No. G142, No. G195. The cows were still out on pasture, only a slight amount of snow covered the field. In one of the pastures, a cow (ear tag Y110) had fetal tissue protruding from the vulva (the cow appeared to be aborting). The owner had observed her bulling earlier.

At Ranch B, M. Mostrom walked through the cattle. One cow (tag No. 176) had what appeared to be "cancer eye" and was to be culled. The ranch owner had started to feed hay to the cows.

*November 30.* The petroleum company held a meeting to review the livestock monitoring data following the pipeline leak (Mostrom, 1994i).

*December 1.* M. Mostrom went to Ranch A to acquire data on livestock treatments and responses throughout 1994 for evaluation of economic costs in a possible toxicological exposure. The ranch owner had started to feed hay to the cows and two composite hay samples were taken; one sample was new hay (ID No. 940694) and one sample was older, 1993 hay (ID No. 940695) (Table 7). Briefly, the protein content was 9.2% and 8.2%, the TDN estimate was 43.9% and 44.1%, the Cu was 5.7 µg/g and 4.4 µg/g, the Ca was 0.61% and 0.56%, and the P was 0.18% and 0.16%, respectively (on a dry-matter basis).

*December 12.* The owners of Ranch B provided the selling weights of steers and some of the heifer calves to M. Mostrom. The owners were incorporating additional selenium mix with the Weatherguard No. 2 mix (Table 8); the cows were consuming one sack of mineral with about five pounds of premix per day over a three-day period.

*June 3, 1995 Ranch B.* Another cow was included in the 1994 field investigations because this cow had respiratory abnormalities in the spring of 1994 (May 4-5. Ranch B). The cow appeared to have clinical signs similar to other animals observed in 1994: weight loss, edema in the cranio-ventral thoracic area, jugular pulse, open mouth breathing, and marked lethargy.

Because the prognosis was poor for recovery, euthanasia of this cow with a bullet in the brain allowed for a comparison of histopathology lesions with cow No. G145 (No. 940244).

The gross necropsy data on cow No. 98 (ID No. 950127) can be found in Appendix B. The cow weighed 605 kg and had approximately five gallons of yellow-tinged fluid in the pleural cavity. The right lung was edematous (75% involvement) and the left lung had 15% involvement as edema. The heart was enlarged and flabby, the liver was swollen and firm to the touch. Microbial culture of lung tissue revealed a growth of *Corynebacterium xerosis*, a bacterium that is considered an opportunistic organism in human patients and not frequently cultured in cattle. The whole blood Se, 243 ng/mL, plasma Cu, 964 ng/mL, and plasma Zn, 1353 ng/mL, concentrations would be considered adequate (Puls, 1990).

The histopathology lesions included chronic proliferative pleuritis and bronchopneumonia, hepatic centrilobular fibrosis and periportal hepatocellular hypertrophy, and non-suppurative tracheitis and squamous metaplasia of tracheal mucosa (Stair and Kosanke, 1997). The liver changes were not thought to be secondary to the pulmonary lesions. The histopathology diagnosis on cow No. 950127 follows:

- (1) Chronic proliferative (fibrous connective tissue) pleuritis and bronchopneumonia
- (2) Splenic hemosiderosis
- (3) Chronic active hepatic congestion with centrilobular fibrosis, mid-zonal hepatocellular fatty change and periportal hepatocellular hypertrophy
- (4) Focal interstitial renal fibrosis with healed renal infarcts
- (5) Mediastinal lymph node – Lymphoid hyperplasia and neutrophilic lymphadenitis
- (6) Popliteal lymph node – Neutrophilic lymphadenitis
- (7) Right renal lymph node – Acute neutrophilic lymphadenitis
- (8) Mild submucosal non-suppurative tracheitis. Squamous metaplasia of tracheal mucosa. Submucosal lymphoid infiltration.
- (9) Degenerative ganglionic neuronopathy and ganglionic interneural lymphoid infiltration involving the Gasserian ganglion
- (10) Peripheral neuropathy involving the sciatic nerve
- (11) Status spongiosa of the spinal cord (degenerative myelopathy).

#### 7.4 Discussion

*Exposure Analysis.* Exposure analyses was done using the available information. For Ranches A and B, the route of exposure to substances leaked from the pipeline was limited to the inhalation. Sources of the volatile substances from the January 1994 pipeline leak were:

- Crude petroleum from the leak
- Products of combustion
- Volatile fractions from the remediation operations.

The leak was estimated to have started on January 6, 1994. The estimated volume of petroleum released into the environment was 40 million cubic meters ( $m^3$ ) of sour gas and 50  $m^3$  of sour condensate. An estimated fifteen  $m^3$  of condensate pooled on the ice was burned on January 8<sup>th</sup> and 11<sup>th</sup>. Excavation and soil washing was done from mid-February through mid-March, 1994. Volatile substances were vented to atmosphere during the sparging operation.

The sour crude petroleum was found to be a highly complex chemical mixture. The crude petroleum was approximately 33 mole-percent hydrogen sulfide ( $H_2S$ ), 43 mole-percent hydrocarbons ( $C_2$  to  $C_{12}$ ), nine mole-percent benzene, toluene, ethylbenzene, and xylene (BTEX), six mole-percent methane ( $CH_4$ ), five mole-percent cyclopentanes, cyclohexanes, and one mole-percent trimethylbenzene, and the remainder was hydrocarbons in the  $C_{13}$  to  $C_{30}$  range. The chemistry of the products of combustion is not known. However, it can be assumed that the products of combustion were a highly complex chemical mixture and were somewhat similar to the findings of Strosher (1996). The ranchers claimed that cattle were exposed to ice smog from burning, and to substances being volatilized during the riverbed remediation operations. Because of emissions from the first ignition, Ranchers A and B were forced to evacuate their domiciles. Ranch A also evacuated their domicile because of emissions form the second ignition. After the ignition, cattle were observed to have signs of eye irritation. Clean-up operations were suspended on February 26, 1994 because of odor complaints from nearby residents.

The cattle were located in the vicinity of the pipeline leak. Cattle on Ranch A were being wintered in the river valley in a pasture that ranged from 0.5 to 2.0 km from the leak site. Immediately after the leak was discovered, cattle on Ranch A were moved to the home yard. Cattle on Ranch B were in winter quarters on the home yard when the leak occurred. Both of the ranch yards are located approximately four km from the leak site.

Other anthropogenic sources of hydrocarbons were identified before, during, and after the pipeline incident. In December 1993 sour gas was emitted from oil wells located at 9-3-34 and 7-3-34. Cattle on Ranches A and B were potentially exposed to these emissions by inhalation route of exposure. Additional pipeline failures occurred. These incidents occurred west to northwest of Ranches A and B in July and September 1994, and cattle on Ranches A and B were potentially exposed to these emissions by inhalation exposure. Another incident occurred on Ranch A in September 1994 when a blowout preventer failed (lease 9-4-34) and oil was sprayed on hay bales, trees and pasture. In this incident cattle were exposed by the inhalation route and possibly the oral route. Because of the high ambient concentrations of hydrogen sulfide, the ranch residents and guests were requested to evacuate. Water flowing through the cattle yard at Ranch B was sampled in November 1993. The creek water was found to contain 3.3 mg/L of extractable hydrocarbons (C43 to C60) and 4 mg oil and grease/L. Because this creek flows through the cattle yard, the cattle had free access (*ad libitum*) to this water and oral exposure could have occurred. The ranchers A and B also claimed that upset conditions in other oil and gas facilities concurrent with the pipeline leak incident also decreased air quality and visibility.

In all of the potential exposures, air quality data for the ambient environment in the vicinity of the cattle was not taken or was not available for use in this investigation.

*Cattle and Clinical Observations.* Ranch A was a 320 head, crossbred cow-calf operation. Ranch B consisted of approximately 160 purebred and crossbred cows. On both ranches, cows were calved in either confined facilities or on pastures close to the house. During the winter and early spring of 1994, hay, nutritional supplements, trace minerals and salt were fed to the cows; the nutrition on both ranches was considered to be adequate. The cold weather in 1994 was a factor considered in the field investigation. For comparison purposes, the weather of 1988 (when the ranch owners reported low mortalities) and 1995 were included for reference (Appendix E).

Following the pipeline break in early January 1994, clinical observations were recorded for cows on both ranches (Table 10). A large portion of the Ranch A cow herd was pastured on range located up to one-quarter mile from the pipeline leak. The cattle on Ranches A and B were located within four kilometers of the pipeline leak and clean-up. The primary clinical signs were irritation to the eyes and respiratory tract with ocular and nasal discharge; some cows also had vaginal discharge and one abortion was reported. Depressed appetite and CNS depression were observed in cows on both ranches. On Ranch B, the 1993 yearling calves showed marked inappetence,

weight loss, and rough hair coats; these animals were on feed longer into the spring of 1994 to regain the lost weight. At the onset of the calving season, the ranch owners reported that a number of cows failed to exhibit signs of impending parturition (calving), and following calving did not display typical expected maternal behavior. In previous years, these cows were good mothers. Some cattle showed atypical aggression towards humans. A number of calves did not want to nurse and showed failure to thrive. At various times throughout the spring, pregnant cows on both ranches exhibited a change in sexual behavior, with aggressive estrus behavior. In part because of the atypical cow behavior and poor nursing response in calves, the ranch owners restricted (in February) the cows to more confined locations for closer observations.

Starting in mid-February, cattle on both ranches were observed displaying varying degrees of proprioceptive-locomotor difficulty that was reflected as abnormal locomotion. In a few cows, this was a non-reversible condition while other animals recovered. On Ranch A, calves from birth to six weeks of age developed acute clinical signs of depression, recumbency, and hypothermia progressing to a rapid death. Hypothermia was also noted in Ranch B calves. The hypothermia was suggestive that the calves had difficulty maintaining body temperature in the immediate post-natal period. The malady was aggravated by cold ambient temperature. The clean-up operations reported several "hot-spots" of clean-up in mid-February (SCLCC, 1994).

*Clinical Pathology.* Cows and calves showing adverse health effects were selectively bled for clinico-pathological evaluation. Deviations from normal values were related to individual responses such as increased white blood counts in infectious disease or a change in serum chemistries reflecting specific organ malfunction. Clinico-pathologic determinations could not be repeated across time. One time in late spring (April-May, 1994) three groups of animals (young calves <10 days of age, calves >10 days, and cows) at AEC and on both ranches were bled for clinico-pathological evaluation. Globulin and total protein concentrations were of particular interest as they can reflect transfer of passive immunity and perhaps dehydration in disease, respectively (Figure 5). Some of the values observed in the ranch animals were depressed compared to the AEC herd.

*Morbidity and Mortality.* Both ranch owners reported an unexpectedly high incidence of sick calves. Approximately 80% of all calves were reportedly treated with various medications; in many cases the owner reported a poor treatment response. Young calves on Ranch A began dying calf mortality on Ranch A was about 12% (37 dead calves/300 calves) with most calves dying in

February through April. Fifty percent (19/37) of the calves that died were <14 days of age. Approximately eight cows were found dead in the summer without premonitory signs.

Ranch B had a 1994 calf mortality of about 16% (26 dead calves/160 calves) with higher mortality in February versus the other months (Figure 7). The death losses were distributed from 14 weeks of age to born dead (included in the <24 hours) with 30% of calf losses <24 hours. Several calves on Ranch B had necrosis of the lower limbs (pododermatitis) possibly related to the inability of calves to maintain their normal body temperature and cold weather. The selenium concentrations in the animals with pododermatitis were not elevated (Nos. 940237, 940238, 940249, 940250).

A variety of diseases and lesions were observed in the animals necropsied in the field investigations. Some of the histopathology lesions observed in the animals would be consistent with inhalation exposure to an irritating substance. These lesions include proliferation of submucosal glands, discharged goblet cells, squamous metaplasia of the tracheal mucosa, submucosal perivascular lymphoid infiltration, and severe intraalveolar edema (Stair and Kosanke, 1997). Because of a lack of air monitoring data and the unique topography of the area, no exposure data was available to establish a "cause and effect" response in this field investigation.

Numerous calves appeared to have proprioceptive difficulties, starting in February. A marked incident in central nervous system abnormalities occurred in late March when three cows out of three hundred were observed staggering and recumbent. One of the cows was euthanized and necropsied with tissues examined histologically, the other two cows lived; one cow continued to stagger until culled from the herd and the other cow appeared to recover. Lesions in the necropsied cow included axonal swelling and demyelination of the trigeminal nerve and accompanying the Gasserian ganglion (Stair and Kosanke, 1997). Numerous calves had suppression or depression of lymphoid tissue that clinically could lead to decreased host resistance and increased infectious diseases and death losses.

These two ranches both experienced increased mortalities as compared with previous years. Figure 8 compares mortality of ranch animals by year. Both ranches had an increased 1994 calf mortality as compared with past years. The increased calf mortalities were not related to changes in the calving pattern on the ranches, because the calving distribution remained fairly

Figure 7 1994 Ranch A (300 Cow-Calf Operation) and Ranch B (160 Cow-Calf Operation) Mortalities Across Time and by Age

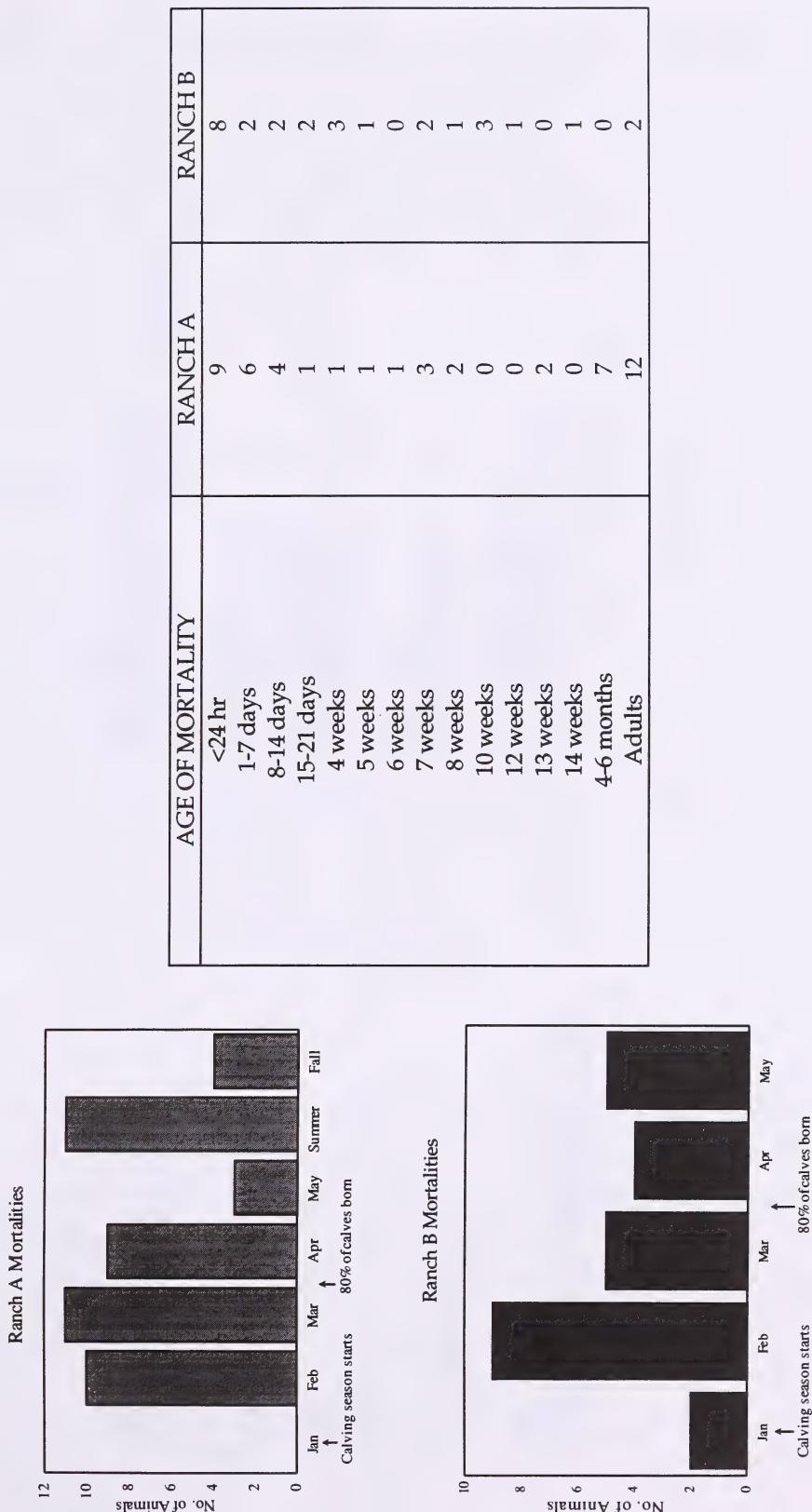
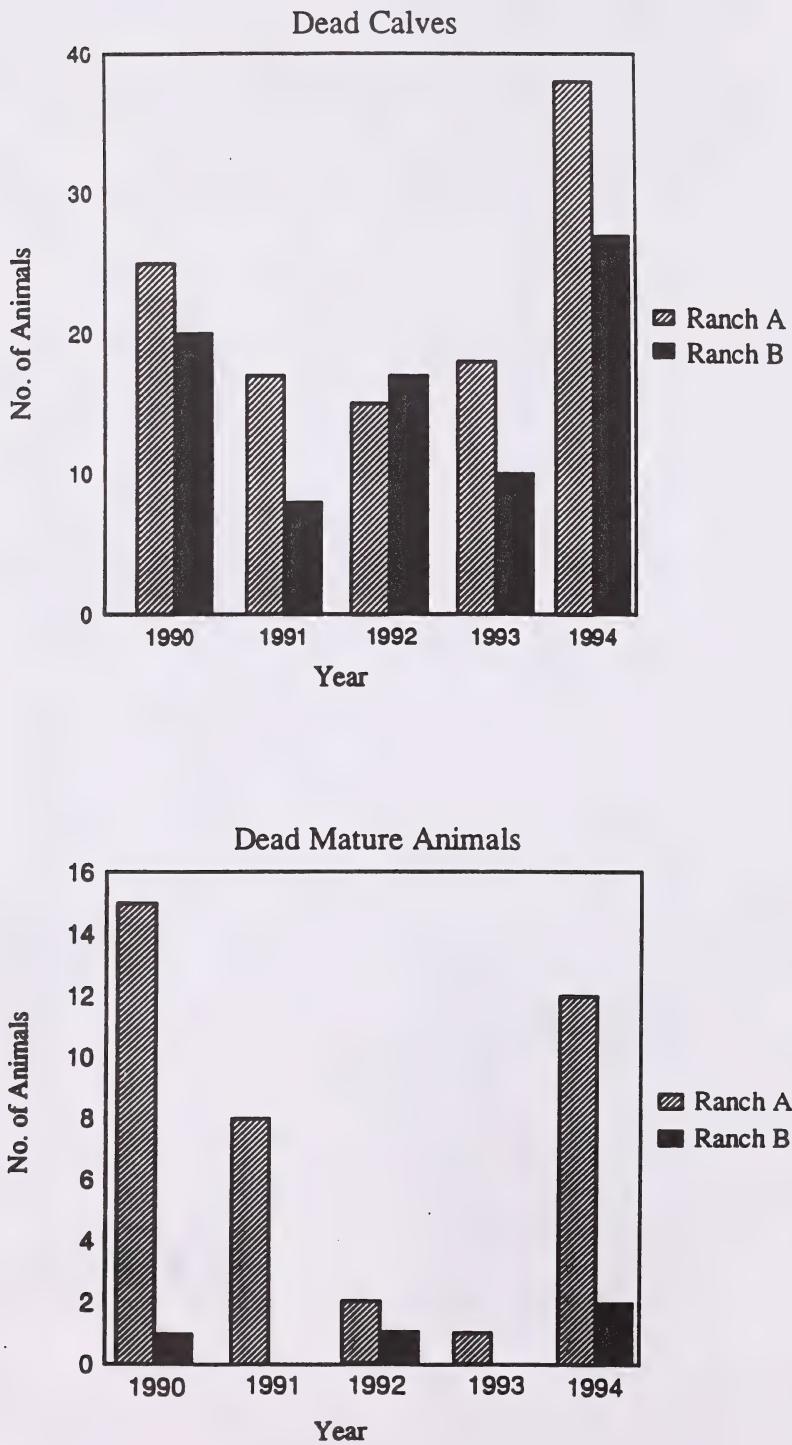


Figure 8

Bar Charts Comparing Mortality in Calves and Cows by Year from Ranch A and Ranch B



similar in the 1990's. Figures 9 and 10 compare the calving distribution across months (January through May) from 1990 to 1995 on Ranch A and Ranch B, respectively.

In addition to increased calf mortality, Ranch A had a marked increase in cow mortality as compared to 1991 through 1993. About 14 adult animals on Ranch A died in 1990, which was suspected of being related to the numerous and varied hydrocarbon exposures during the previous calving season. Ranch B experienced low adult mortalities over the past five years.

*Trace Nutrients.* The ranches are located in a geographic region that is selenium and copper deficient. Both ranchers supplemented their cattle with selenium and copper. Figure 11 illustrates the liver selenium and copper concentrations ( $\mu\text{g/g}$  on a dry matter basis) from 1994 post-mortem animals. The liver selenium and copper concentrations ranged from deficient or marginal to adequate and toxic interpretations. The lesions associated with Cu and Se poisoning in cattle were not observed in calves with toxic Se and Cu concentrations in this field investigation (Kelly, 1985; Yager and Scott, 1985). The data is distributed similar to a Gaussian curve for a sample population.

*Cattle Productivity Data.* During 1994, Ranch A had ten sets of twin calves from about 300 cows, and Ranch B had eight sets of twin calves from approximately 160 cows. Ranch A has had an increasing twinning rate since 1990; however, Ranch B has had a relatively low twinning rate in the past five years. Evaluation of available data on open cows (non-pregnant) for the 1995 calving season showed no significant change compared to historical data. No marked changes were observed in the 1994 calf selling weights, as compared with historical data (Figure 12). In 1992, a portion of the Ranch A calves were exposed to a hydrocarbon spray in early fall and showed a 25 kg depression in selling weights as compared with calves that had no known hydrocarbon exposure.

## 7.5 Summary

The January clinical observations of irritation to respiratory, ocular, and vaginal mucous membranes in cows, CNS depression, and inappetence are compatible with airborne irritations observed in cattle exposed to sour gas (Oehme *et al.*, 1996; Coppock *et al.*, 1986a; Edwards, 1992). These cows in this field investigation were located within four kilometers to less than one-half kilometer from the actual pipeline leak. The observed proprioceptive locomotor deficits are similar to neuropathies associated with assorted petroleum hydrocarbon exposures in other species

Figure 9 Total Calves Born Per Month by Year on Ranch A

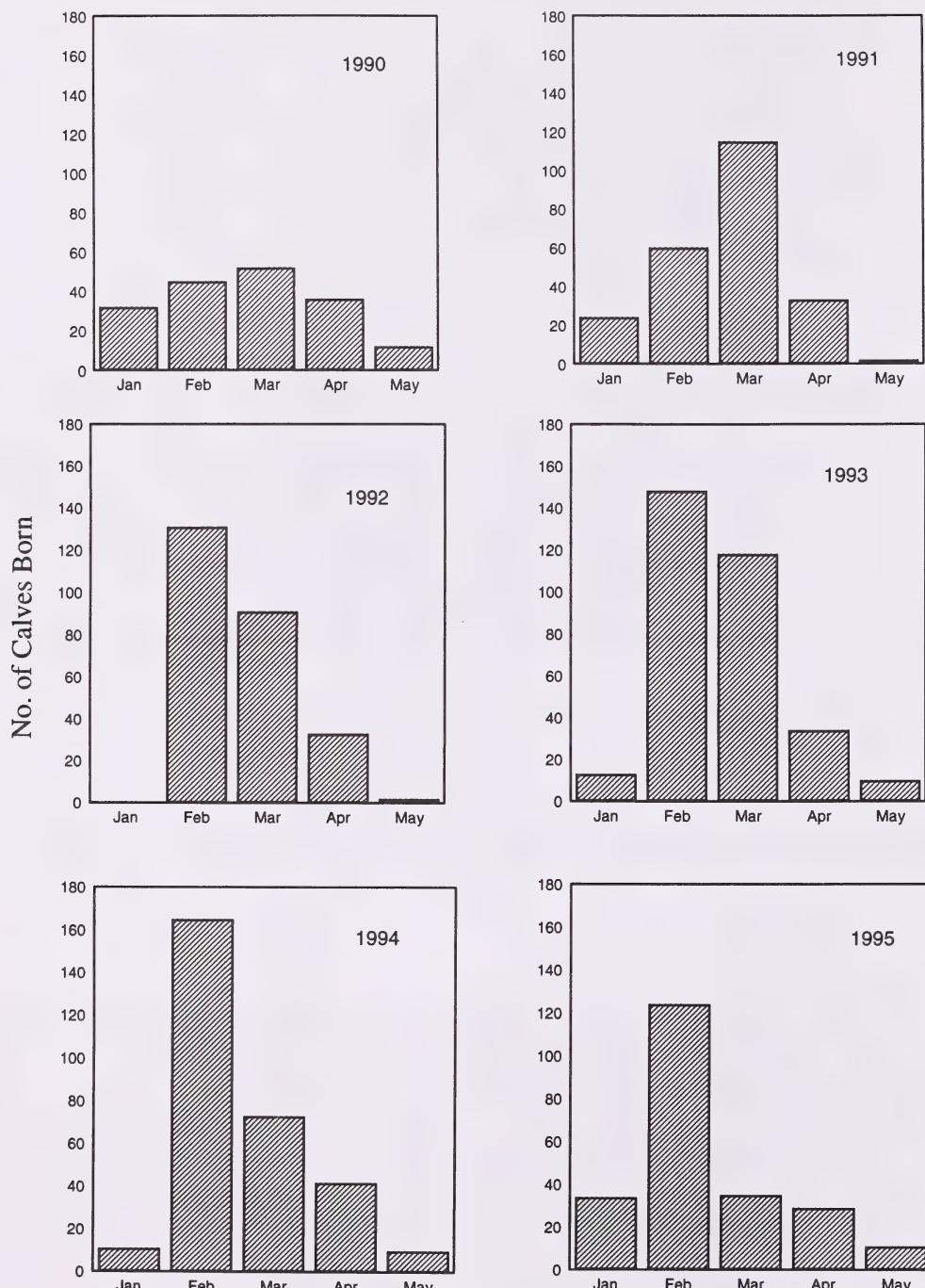


Figure 10 Total Calves Born Per Month by Year on Ranch B

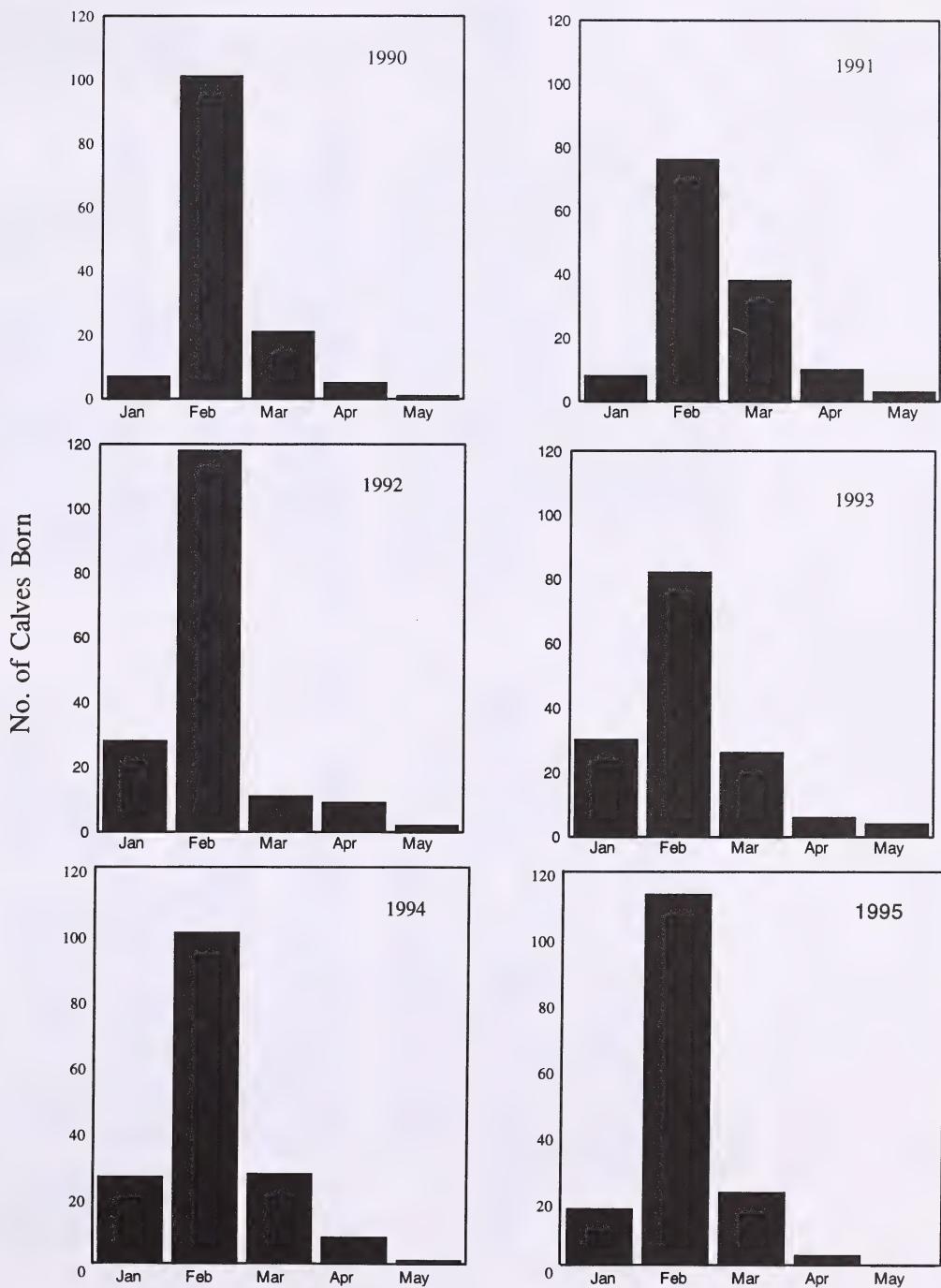


Figure 11 Bar Charts of Liver Selenium and Liver Copper Concentrations ( $\mu\text{g/g}$ ) from 1994 Necropsied Animals on Ranch A and Ranch B with Interpretation of Nutritional Status (Puls, 1990)

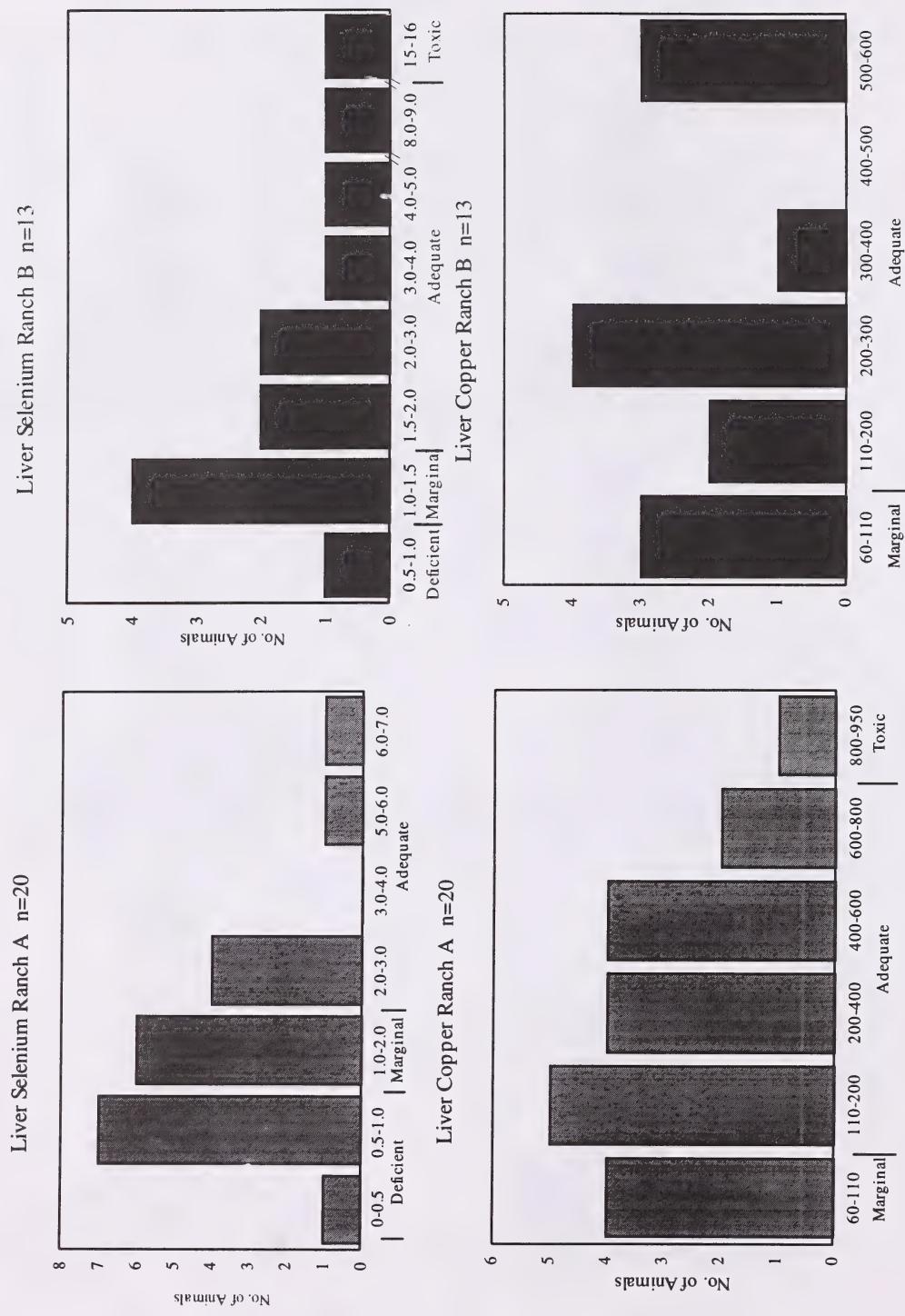
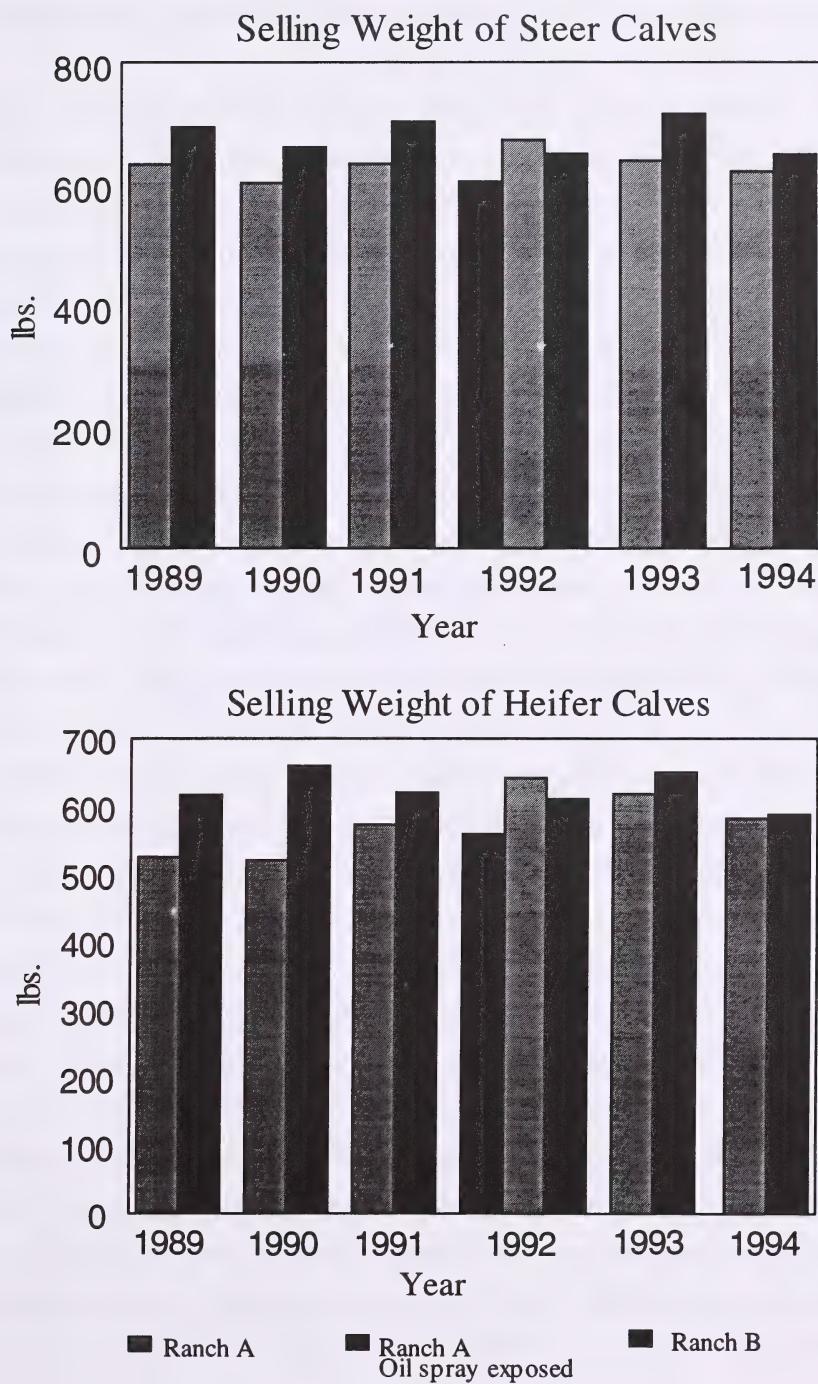


Figure 12 Bar Charts Comparing the Average Selling Weights of Steer and Heifer Calves by Year from Ranch A and Ranch B



(Gerard, 1960). In particular, the hexacarbons,  $\gamma$ -diketones, such as *n*-hexane are associated with neuropathies (Andrews and Snyder, 1991). The changes from normal cattle behavior, the CNS depression, and the proprioceptive deficits were interpreted by the authors as involving limbic system modulation.

Both ranches had a higher mortality in 1994 as compared with previous years. Some of these deaths are explainable, while others are unsolved. No consistent pattern of disease outbreak was detected on either ranch. Airborne irritants can be an initiating factor with natural progression to infectious diseases (Oehme *et al.*, 1996; Khan *et al.*, 1991; Suleiman, 1987). An increased incidence of abnormal clinical signs and calf death loss was associated temporarily with "hotspot" emissions during clean-up.

Occupational exposure to *n*-hexane can inhibit peripheral blood neutrophil chemotaxis, an important immune function (Governa *et al.*, 1994a; Governa *et al.*, 1994b). The histopathology from this study indicates that a number of animals on the two ranches had pneumonia and tracheitis and hypoplasia of the lymphoid tissue of the thymus, spleen and lymph nodes. Lymphoid hypoplasia may, in some animals, reflect an immature immune system, but nonetheless could result in increased disease susceptibility. Lymphoid atrophy has been reported in a variety of species exposed to petroleum oils (Leighton, 1990; Couillard and Leighton, 1990; Juck, 1981). Mallards treated orally with crude oil had increased mortality in a bacterial challenge of host resistance (Rocke *et al.*, 1984). Lymphoid atrophy can lead to immunosuppression in an animal and manifest as increased infectious disease. Opportunistic bacteria cultured from human patients, *Enterococcus faecalis* and *Corynebacterium xerosis*, were detected in tissues of calves and a cow, respectively, in this field study.

A brief survey of the immunoglobulin status of young calves on these ranches revealed that several of the calves had low gamma globulin concentrations reflecting failure of passive transfer of colostrum. This occurred despite the efforts of the ranchers to ensure adequate transfer of colostrum to calves within six hours. The authors did not determine whether the inadequate transfer of colostrum was because of low immunoglobulins concentration in the dam's colostrum, adequate transfer, or inadequate uptake of immunoglobulins by the calf. Considering the histopathological findings of lymphoid hypoplasia in many calves, the immunoglobulin (gamma globulin) status of young calves or adequate transfer of colostrum, should be a consideration in exposure of neonatal animals to petroleum hydrocarbons.

The cold weather temperatures in February 1994 are another factor that could interact with environmental pollutants, further stressing the animals. However, 1988 was a relatively cold winter and highly unexplained calf losses reported did not occur on the ranches. The cattle in 1994 were exposed to emissions not only from the pipeline leak, but also from other petroleum industrial activities. An interaction between gas pollutants and organic solvents would not be unexpected, but effects may be difficult to predict (Krishnan and Brodeur, 1994).

The 1994 calf selling weights and rates of open cows were similar to past years on both ranches. However, the twinning rate was increased on both Ranches A and B. Increased twinning rates have been reported in cattle and human populations exposed to air pollution from incinerators (Lloyd *et al.*, 1988). The observations in the ranch cattle appear to reflect clinical signs observed in other species exposed to petroleum products.

This toxicology field investigation was in response to a request to evaluate the potential impact of a multiphase pipeline leak and clean-up on cattle health. As a field investigation into a toxicological event, not all factors can be controlled as compared with a controlled experiment. Because of the lack of exposure data, a dose-response or effect-response relationship could not be established. The authors did utilize definitive veterinary medical diagnostic procedure to establish etiologic agents of disease in many of the affected animals. This report is exemplary in its attempt to determine the underlying causes of the clinical signs observed in cattle on these ranches during the pipeline leak and clean-up. A variety of factors were evaluated in this investigation. No consistent pattern of disease could explain the high death losses observed in calves on the ranches. Various disease etiologies were determined or indicated as possible contributors in the detailed pathological examinations. Bovine virus, diarrhea virus and *Salmonella* were suspected in the histopathological evaluation in several calves but no positive evidence of these diseases was found using diagnostic virology/bacteriology testing nor were the typical clinical signs of the diseases observed in the herds. Corona virus was suspected in several calves but was not consistently demonstrated with diagnostic immunohistochemistry nor was neonatal diarrhea a consistent or persistent problem in these herds. Coccidia and clinical signs of diarrhea were found in animals at both ranches, however, a diarrhea outbreak in cattle was not observed by the investigators or ranchers. Clinical signs or histopathological lesions of selenium or copper poisoning were not reported in calves with high to high-toxic concentrations of selenium or copper. Observed clinical signs and histopathological lesions in the respiratory, nervous and lymphoid tissues can be

associated with exposure to volatile hydrocarbons released at the time of the leak and during the subsequent clean-up operations.

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## **APPENDIX A**

### **METHODS (GLP SOPS) USED FOR LABORATORY AND FIELD PROCEDURES**

The GLP SOPs (methods) are available upon request from the Alberta Research Council (Vegreville). To save publication costs, these methods have not been included in this report.



**APPENDIX B**

**NECROPSY FINDINGS**

DIVIDED INTO SUBSECTIONS FOR RANCHES A AND B



Toxicological Pathology Record Ranch A

AEC No. <b>930565</b>	Date of Necropsy 93.12.08	
Species Bovine	Breed Simmental X	Sex Male
Age Fetus	If found dead, estimated No. of Hours 72 to 96 hours	

History

(Dam # 930593) : Plasma Cu 1,294 ng/mL  
 Plasma Se 34 ng/mL      Whole blood Se 41 ng/mL)

Owner reported smelling sour gaseous odors for > four hours on December 2 and again on December 4 - 5. Cows were located in adjacent pastures to oil wells. Cow aborted on/ or about December 4. Owner did not observe the cow showing other clinical signs; cow cleaned without problems.

Gross Findings

Weight 9.08 Kg

Crown-rump length 60 cm

Fetus - frozen when brought to Centre; appeared in good body condition, autolyzed.

Hair around eyes and muzzle.

Spleen appeared enlarged, approximately 15 cm long and weighed 42 g; no other gross abnormalities.

Virus isolations and FA Tests for Infectious Bovine Rhinotracheitis and Bovine Virus Diarrhea were negative. Formalin tissue sections of spleen, liver and kidney examined by avidin biotin complex immunoperoxidase were negative to both Bovine Herpes Virus Type 1 and Bovine Virus Diarrhea Virus (Diagnostic Immunology, WCVM, Saskatoon, SK).

Kidney Se 1,050 ng/g*	Liver Se 724 ng/g
Cu 16 µg/g	Cu 145 µg/g
Hg <125 ng/g	Hg <125 ng/g

\* Tissue trace minerals are reported on a dry weight basis

Toxicological Pathology Record Ranch A

AEC No. <b>930566</b>	Date of Necropsy 93.12.08	
Species Bovine	Breed Angus X	Sex Female
Age Fetus	If found dead, estimated No. of Hours 72 to 96 hours	

History (Dam #930599) : Plasma Cu 1,288 ng/mL

Plasma Se 67 ng/mL Whole blood Se 177 ng/mL)

Owner reported smelling sour gaseous odors for > four hours on

December 2 and again on December 4 - 5. Cows were located in adjacent pastures to oil wells.

Cow aborted on/ or about December 4. Owner did not observe the cow showing other clinical signs; cow cleaned without problems.

Gross Findings

Weight 14.47 Kg

Crown-rump length 68 cm

Fetus - frozen when brought to Centre; appeared in good body condition, autolyzed.

Hair around eyes and muzzle.

Multichambered cyst on posterior aspect of liver, filled with about 400 mL of blood tinged fluid.

Virus isolations and FA Tests for Infectious Bovine Rhinotracheitis and Bovine Virus Diarrhea were negative. Formalin tissue sections of spleen, liver and kidney examined by avidin biotin complex immunoperoxidase were negative to both Bovine Herpes Virus Type 1 and Bovine Virus Diarrhea Virus (Diagnostic Immunology, WCVM, Saskatoon, SK).

Kidney Se 1,750 ng/g*	Liver Se 1,190 ng/g
Cu 114 µg/g	Cu 145 µg/g
Hg <125 ng/g	Hg <125 ng/g

\* Tissue trace minerals are reported on a dry weight basis

## Toxicological Pathology Record Ranch A

AEC No. <b>940134</b>	Date of Necropsy 94.02.14	
Species Bovine	Breed Charolais	Sex Female
Age 5 days	If found dead, estimated No. of Hours 24 hours	

### History (Dam Gr 147)

Calf was ataxic - dog tracking, staggering; appearance of being loose jointed in back legs with the nose pointing out (like a hunting dog)[VIDEO]. Calf appeared "stupid" - did not want to suck and had to be trained. Calf was tubed periodically, given colostrum and vitamin supplement. Calf became recumbent 94.02.12, tubed with fluids, placed in a small, portable heated enclosure with ventilation ("hot box"). Calf died 94.02.13.

Birth weight 39.1 Kg.

### Gross Findings

Weight 41 Kg

Posterior, dorsal tongue showed ecchymotic hemorrhages.

Frothy fluid in trachea and lungs.

Lungs - wet appearance, fluid oozed on cut surfaces (> 50% lung edematous appearance).

Kidneys appeared enlarged, "puffy appearance".

Ecchymotic hemorrhages on serosal surface of major vessels of the heart (aorta, pulmonary artery/vein).

Streaks of hemorrhage on epicardial surface of both auricles and the wall of the left ventricle.

Virus isolations and FA Tests for Infectious Bovine Rhinotracheitis and Bovine Virus Diarrhea were negative.

### BACTERIOLOGY

Samples from kidney, spleen, duodenum and lymph node were cultured anaerobically and aerobically on Edwards media with blood, on EMB and campylobacter media. Broth cultures were made and after 24 hours at 37°C they were cultures on MacConkey in a check for salmonella. All Edwards media plates showed a good growth of colonies of a non-hemolytic streptococcus, which grew better anaerobically. The EMB plates showed heavy contamination with coliforms and there was no indication of campylobacter or salmonella (Palliser Animal Health Laboratories, LTD, Lethbridge, AB).

Kidney Se 3,100 ng/g*	Liver Se 5,700 ng/g
Cu 12 µg/g	Cu 948 µg/g

\* Tissue trace minerals are reported on a dry weight basis

## Toxicological Pathology Record Ranch A

AEC No. <b>940153</b>	Date of Necropsy 94.02.27	
Species Bovine	Breed Simmental/Here X	Sex Male
Age 4 days	If found dead, estimated No. of Hours < 8-10 hours	

### History (Dam Gr 202)

Calf stomach tubed with warm fluids, treated with Liquamycin®. Kept in barn, could not sustain body temperature in "hot box". Eyes on calf normal appearance, but "nose and ears seem to freeze on calves for no reason" according to the owner.

### Gross Findings

Weight 55.5 Kg

Diffuse petechial hemorrhages in fascia and subcutaneous tissue of neck, thorax and abdomen.

Blood tinged - yellowish fluid in abdomen ( $\pm$  250 mL).

Lungs: apical and cardiac lobes diffusely red and consolidated (bilateral)

right lung surface - emphysematous appearance

$\approx$  60 % lung involvement.

Hemorrhage on mesenteric attachment of spleen to abomasum.

Eccymotic hemorrhage on epicardial surface of right auricle.

Hemorrhage on epicardial surface along right atrium-ventricle.

Hemorrhage on endocardial surface at the base of the papillary muscles of both left and right ventricle, small blood "cysts" at base of papillary muscles.

Kidneys - dark red, pulpy, friable.

Hemorrhage on spinal cord in thoracic area.

Milk curd in stomach.

Virus isolations and FA Tests for Infectious Bovine Rhinotracheitis and Bovine Virus Diarrhea were negative. Formalin tissue sections of gastrointestinal tract examined by avidin biotin complex immunoperoxidase were negative to Bovine Coronavirus, Rotavirus, and Bovine Virus Diarrhea Virus; a spleen section was negative to *Salmonella sp.* (Diagnostic Immunology, WCVM, Saskatoon, SK).

### BACTERIOLOGY

Tissue samples were set up on blood agar and Edwards media with and without oxygen, EMB, MacConkey media (after enrichment for salmonellae), and campylobacter medium. No campylobacter or salmonellae were isolated. Edwards media: more growth without oxygen, clear non-esculin fermenting colonies of streptococci in kidney (few); lung (heavy growth); liver (few); lymph node (heavy growth); spleen (heavy growth). EMB media: all tissues showed a heavy growth of coliforms. The streptococci were identified as *Enterococci faecalis*.

Kidney Se 4,200 ng/g\*      Liver Se 2,090 ng/g  
Cu 21  $\mu$ g/g      Cu 344  $\mu$ g/g

\* Tissue trace minerals are reported on a dry weight basis

## Toxicological Pathology Record Ranch A

AEC No. <b>940154</b>	Date of Necropsy 94.02.27	
Species Bovine	Breed Angus/Charolais X	Sex Female
Age 5 days	If found dead, estimated No. of Hours 24 hours	

### History (Dam Gr 186)

Calf appeared normal at 06:15 on 94.02.26 but was "flat out" at 07:30 (could not record a body temperature). Warm fluids given by stomach tube, placed in the "hot box" (could not even record a rectal temperature). Dead at 09:00 on 94.02.26.

### Gross Findings

Weight 37.3 Kg

Froth and hemorrhages in nasal passages.

Froth in trachea.

Right lung - diffusely red, meaty - consolidated (<45% total lung involvement).

Left ventricle - petechial hemorrhages on epicardium.

Right and left atrioventricular valves show hemorrhage (approximately .25 X .25 cm).

Milk curd in stomach.

Virus isolations and FA Tests for Infectious Bovine Rhinotracheitis and Bovine Virus Diarrhea were negative.

### BACTERIOLOGY

Heavy growth of non esculin-fermenting streptococcal colonies only in the lung, a few colonies in the liver, lymph node and spleen. The streptococci were identified as *Enterococci faecalis* (Palliser Animal Health Laboratories, LTD, Lethbridge, AB).

Kidney Se 6,300 ng/g*	Liver Se 6,990 ng/g
Cu 15 µg/g	Cu 570 µg/g

\* Tissue trace minerals are reported on a dry weight basis

## Toxicological Pathology Record Ranch A

AEC No. <b>940155</b>	Date of Necropsy 94.02.27			
Species Bovine	Breed Saler/Charolais X	Sex Female		
Age 7 days	If found dead, estimated No. of Hours 72 hours			
History (Dam Gr 131)				
Calf appeared normal at 05:00 on 94.02.24 but was dead at 06:30.				
Gross Findings				
Weight 34.1 Kg				
Calf was frozen. Petechial hemorrhage on right ventricle epicardium. Small "blood cysts" on atrioventricular valves.				
Virus isolations and FA Tests for Infectious Bovine Rhinotracheitis and Bovine Virus Diarrhea were negative.				
Kidney Se 2,680 ng/g*	Liver Se 2,740 ng/g			
Cu 29 µg/g	Cu 710 µg/g			
* Tissue trace minerals are reported on a dry weight basis				

## Toxicological Pathology Record Ranch A

AEC No. <b>940158</b>	Date of Necropsy 94.03.08	
Species Bovine	Breed Charolais	Sex Male
Age 3 weeks	If found dead, estimated No. of Hours 24 hours	

### History (Dam Gr 213)

Found dead in pasture. Owner did not observe animal sick or treat animal.  
A large portion of the small intestine had been pulled out from the navel and was gone.  
Birth weight 47.7 Kg.

### Gross Findings

Weight 72.3 Kg

Good amount of body fat present.

Lungs: diffuse, bilateral red appearance - particularly of caudo-dorsal lobes)  
"wet" - edematous appearance, feel heavy, meaty appearance on cut surfaces  
express white froth out of trachea  
>75% lung involvement.

Kidney - well circumscribed round-to-oval areas (1 to 1.5 cm in diameter) of greenish discoloration - soft and contain greenish discharge on surface; patchy hemorrhages scattered on surface.

Liver - scattered pale appearing areas.

Heart - darker red appearance on left ventricle epicardial surface.

Formalin tissue sections of liver, lung, and spleen examined by avidin biotin complex immunoperoxidase were negative to *Salmonella sp.* (Diagnostic Immunology, WCVM, Saskatoon, SK).

### BACTERIOLOGY

Heavy growth of coliforms from tissues on EMB media. There was heavy growth on Edwards medium from the kidney which when plated out on blood agar was non-hemolytic and did not have the appearance of colonies of *H. somnus*. A primary culture of the lung on blood agar showed no colonies with the appearance of *Pasteurella hemolytica* or *Haemophilus somnus*. Because of the very heavy coliform contamination failure to demonstrate *P. hemolytica* of *H. somnus* was not unexpected (Palliser Animal Health Laboratories, LTD, Lethbridge, AB).

Kidney Se 2,900 ng/g*	Liver Se 874 ng/g
Cu 14 µg/g	Cu 125 µg/g

\* Tissue trace minerals are reported on a dry weight basis

## Toxicological Pathology Record Ranch A

AEC No. <b>940159</b>	Date of Necropsy 94.03.08			
Species Bovine	Breed Charolais	Sex Male		
Age 4 days	If found dead, estimated No. of Hours < 8 - 10 hours			
History (Dam Gr 144)				
Found dead - no clinical signs.				
Gross Findings				
Weight 45 Kg Lungs: Diffuse scattered areas of redness, edema (not localized to a dorsal or ventral pattern); involves areas in all lobes (100 % involvement). Scattered areas of consolidation. Heart: scattered petechial hemorrhages on epicardium (base of right ventricle and left atrium). Diffuse hemorrhage on tricuspid valve and left atrium endocardium.				
Milk curd in stomach.				
<b>BACTERIOLOGY</b> Alpha-hemolytic streptococcus grew anaerobically on selective media of lymph node, lung and kidney samples. Liver, lung, kidney, spleen, and lymph node gave a heavy growth of coliforms.				
Kidney Se 1,780 ng/g* Cu 11 µg/g	Liver Se 2,160 ng/g Cu 541 µg/g			
* Tissue trace minerals are reported on a dry weight basis				

## Toxicological Pathology Record Ranch A

AEC No. <b>900566</b>	Date of Necropsy 94.03.16	
Species Bovine	Breed Simmental	Sex Female
Age 6 to 7 years	If found dead, estimated No. of Hours < 12 hours	

### History

94.03.10 - local veterinarian reported that cervix on cow was partially dilated. A dead calf (male - about 2 weeks premature) was removed from uterus. Local veterinarian recorded about 15 gallons of fluid in amniotic sac. Fetus postmortem report: autolytic calf with no inflammatory reaction to the presence of the bacteria. Uniform population of a single organism, in vascular structure of both liver and kidney (long, rod-shaped organisms).

94.12.06

Plasma Se	97 ng/mL
Plasma Cu	232 ng/mL
WBlood Se	202 ng/mL

### Gross Findings

Weight ≈ 680 Kg

Normal amount of body fat for adult cow.

Ecchymotic hemorrhages in subcutaneous tissue and fascia surrounding trachea.

Ecchymotic hemorrhages on mucosal lining of trachea.

Right apical lung lobe - hemorrhages, heavy, ventral aspects of left and right lung lobes show consolidation (50% lung involvement).

Hemorrhages in mesentery attachment of spleen.

Scattered epicardial hemorrhages on both left and right ventricles.

Urinary mucosa - scattered hemorrhages and emphysema.

Right uterine horn - slightly enlarged with about 1 L of bloody fluid.

Kidney Se 3,670 ng/g*	Liver Se 652 ng/g
Cu 16 µg/g	Cu 94 µg/g

\* Tissue trace minerals are reported on a dry weight basis

## Toxicological Pathology Record Ranch A

AEC No. <b>940236</b>	Date of Necropsy 94.03.18			
Species Bovine	Breed Charolais	Sex Female		
Age 24 days	If found dead, estimated No. of Hours 24 hours			
History (Dam Gr 40)				
Found dead in pasture - no clinical signs. Blood on nares. Birth weight 41.8 kg.				
Gross Findings				
Weight 59.1 Kg				
Good body fat condition. White froth in trachea. Right and left apical lung lobes appear wet (edematous) and red; heavy (≈45% lung involvement) Scattered petechial hemorrhages on left and right ventricle epicardium. Hemorrhage on left ventricle papillary muscle. Fibrous adhesions between liver and diaphragm (hard to break down). Enlarged liver - left lobe contains multiple, scattered foci of .5 - 1 mm round white areas - throughout lobe. Adhesions between liver and small intestine. Umbilical cord contains a reddish, thick fluid.				
Milk curd in stomach.				

## Toxicological Pathology Record Ranch A

AEC No. <b>940242</b>	Date of Necropsy 94.03.29	
Species Bovine	Breed Saler/Simmental X	Sex Female
Age 5 weeks	If found dead, estimated No. of Hours 1 to 5 hours	

### History (Dam Gr 91)

Found dead in pasture - no clinical signs.

### Gross Findings

Weight 63.6 Kg

Good body fat and muscle condition; frozen ears.

Petechial hemorrhage (1.5 cm diameter) near greater curvature of abomasal mucosa.

Red consolidation of right apical lung lobe (ventral aspect) and left dorsal lung lobes (<45 % lung involvement)

Appearance of blood tinged intestinal contents in jejunum, not in the remainder of intestinal tract.

Milk curd in abomasum; rumen full of hay.

Kidney Se 4,316 ng/g\*

Cu 38 µg/g

Liver Se 800 ng/g

Cu 574 µg/g

Fe 363 µg/g

\* Tissue trace minerals are reported on a dry weight basis

## Toxicological Pathology Record Ranch A

AEC No. <b>940243</b>	Date of Necropsy 94.03.26			
Species Bovine	Breed Simmental/Angus X	Sex Female		
Age 11 days	If found dead, estimated No. of Hours ≈ 24 hours			
History (Dam Gr 50)  Calf found dead.				
<b>Gross Findings</b>  Weight ≈ 55 Kg  Samples taken by owner and placed in 10% buffered formalin.  Local veterinarian described postmortem : Epicardial ecchymosis, peritoneal ecchymosis, hemorrhage into omentum at junction of abomasum ≈ 10" diameter				

## Toxicological Pathology Record Ranch A

AEC No. <b>940244</b>	Date of Necropsy 94.04.04			
Species Bovine	Breed Black Angus	Sex Female		
Age 6 to 8 years	If found dead, estimated No. of Hours Euthanized - shot in head (.22)			
<b>History</b> Owner observed animal incoordinated (unable to get up on front legs), staggering, and recumbent on 94.03.26 [VIDEO] Animal had not calved; blood samples were taken by local veterinarian and animal given intravenous calcium. 94.03.30 Animal was recumbent, drinking and eating (hay and pelleted grain with monensin). Temperature normal 39°C, slow rumen motility. Animal pregnant - feet at pelvic inlet. Blood samples taken, given Dexamethasone (terminate pregnancy), 2 L electrolytes and 500 mL Calcium intravenous. (Delivered 152 lb live, bull calf 72 hours later.) Owner tried to raise animal in a sling/ belt and observed damage to stifle. Animal killed and necropsied.				
<b>Gross Findings</b>				
Weight ≈ 545 Kg				
Lungs: scattered areas of consolidation in ventral portion of cardiac and apical lobes; emphysema of dorso-caudal lobes (≈ 35 % lung involvement).				
Heart - hemorrhage on right atrioventricular valve and on right ventricle endocardium at the base of the papillary muscle.				
Left stifle joint - ruptured cruciate ligaments and extensive fibrin and blood around distal femur and proximal tibia.				
Jejunum - hemorrhage on serosa of about a 25 cm section (owner used belly band to lift cow?)				
Uterus - right horn enlarged - no placenta- but blood tinged fluid in horn.				
Rumen - full of hay and grain.				
Right adrenal - fluid filled cyst in medulla area.				
Formalin tissue section of kidney infiltrating cells examined by direct immunoperoxidase diffusely stained for Bovine Immunoglobulin G (heavy and light chains) confirming the plasma cell origin of the population, (Diagnostic Immunology, WCVM, Saskatoon, SK).				
Kidney Se 7,033 ng/g*	Liver Se 1,098 ng/g	Serum VE 2.56 µg/mL		
Cu 15 µg/g	Cu 214 µg/g			
	Fe 600 µg/g			
* Tissue trace minerals are reported on a dry weight basis				

Toxicological Pathology Record Ranch A

AEC No. <b>940245</b>	Date of Necropsy 94.03.30	
Species Bovine	Breed Simmental/Saler/CharX	Sex Male
Age Stillborn	If found dead, estimated No. of Hours >36 hours	

History (Dam Gr 208)

Cow was "bulling" five days prior to calving. Two days prior to calving cow did not have any milk. Calf was pulled (calf intact and hair did not pull off body - did not appear autolytic to the owner) and the placenta came with the calf. The owner reported that the placenta was already greenish color (necrotic?) when pulled with the calf.

Gross Findings

Weight 59 Kg

Autolytic condition.

Excellent body condition in that fat very evident around kidneys and heart.

Lungs did not float in water.

Small "blood filled cysts" on right atrioventricular valve.

Formalin tissue sections of spleen examined by avidin biotin complex immunoperoxidase were negative to both Bovine Herpes Virus Type 1 and Bovine Virus Diarrhea Virus (Diagnostic Immunology, WCVM, Saskatoon, SK).

Kidney Se 4,198 ng/g*	Liver Se 1,544 ng/g
Cu 33 µg/g	Cu 686 µg/g
	Fe 552 µg/g

\* Tissue trace minerals are reported on a dry weight basis

## Toxicological Pathology Record Ranch A

AEC No. <b>940246</b>	Date of Necropsy 94.03.26	
Species Bovine	Breed Black Angus X	Sex Female
Age 7 weeks	If found dead, estimated No. of Hours < 12 hours	
<b>History (Dam Gr 127)</b> Found dead in pasture. Local veterinarian did necropsy: described severe peritonitis, abomasal wall perforated and hemolytic.		
<b>Gross Findings</b>  Samples taken by owner and placed in 10% buffered formalin: liver, fat, kidney.		

## Toxicological Pathology Record Ranch A

AEC No. <b>940247</b>	Date of Necropsy 94.03.30			
Species Bovine	Breed Simmental X	Sex Male - castrated		
Age one year	If found dead, estimated No. of Hours Shot in brain			
<b>History (Dam White tag 23)</b> 94.01.13 - local veterinarians amputated prolapsed rectum and placed a pursestring suture around rectal sphincter. Treatment with Penicillin (im). Local veterinarians reported lice on animal, coccidia and nematodirus. Blood work: PCV of 20% (24-46% normal range).				
Animal placed in pen and provided hay and pelleted grain. I observed calf 94.01.20 - animal gaunt and few lice observed. Animal given long acting tetracycline, B-complex, selenium/vitamin E (Dystosel®), and pour-on (Lysoff® - fenthion). Animal observed periodically over spring- continued to do "poorly" (anorectic) and in late March showed evidence of sloughing hind feet.				
<b>Gross Findings</b>				
Weight ≈ 386 Kg				
Dorso-caudal lung lobes - consolidation (<45 % lung involvement). Localized thickening of mucosal surface of abomasum (greater curvature). Ecchymotic hemorrhage of right ventricle epicardium. Adhesions between urinary bladder and terminal colon. Both lateral claws of hind legs sloughed - necrotic tissue. Medial claws almost sloughed on both hind feet.				
Kidney Se 5,734 ng/g * Cu 15 µg/g	Liver Se 699 ng/g Cu 398 µg/g Fe 328 µg/g			
* Tissue trace minerals are reported on a dry weight basis				

Toxicological Pathology Record Ranch A

AEC No. <b>940251</b>	Date of Necropsy 94.04.04	
Species Bovine	Breed Simmental/Saler X	Sex Female
Age 7 weeks	If found dead, estimated No. of Hours Euthanyl Forte (iv)	

History (Dam Gr 249)

Illness on approximately February 26 or 27, 1994, which coincided with the owner's report of odors and the report from Shell of two more "hot spots" in river. Calf was depressed, hypothermic and anorectic (five calves died on February 27 to 28, 1994) and treated with electrolytes, ampicillin (Polyflex® at 10 mg/lb bid) and Gentocin® or Amiglyde-V® (amikacin at 10 mg/lb bid), and later with Trimodox® (trimethoprin /sulfadoxine). 94.03.30 - given 3 mL Gentocin, 1000 mL Lactated Ringers and B-vitamins (iv). Temperature - 36.8°C in heated quonset; cachectic animal.

Birth Weight 41.8 kg.

Gross Findings

Weight 64 Kg

Blood samples taken prior to necropsy.

No gross lesions observed in lungs.

Small (<1 cm) dark red area on left atrioventricular valve.

Liver - diffuse orangish - tan colorations (samples taken near bile duct and left lobe).

Rumen - small amount of hay.

Kidney Se 3,423 ng/g*	Liver Se 359 ng/g
Cu 14 µg/g	Cu 89 µg/g
Fe 97 µg/g	

\* Tissue trace minerals are reported on a dry weight basis

Toxicological Pathology Record Ranch A

AEC No. <b>940288</b>	Date of Necropsy 94.04.14	
Species Bovine	Breed Charolais X	Sex Male
Age 8 weeks	If found dead, estimated No. of Hours >24 hours	

History (Dam Bk 44)

Found dead in pasture - no clinical signs.

Birth weight 53.6 Kg.

Gross Findings

Weight 114 Kg

Good body condition - fat around kidneys, well-muscled.

Small "blood-filled" cysts on left atrioventricular valve.

Hemorrhage on right ventricle epicardium (about 2.5 cm from coronary sulcus).

Ecchymotic hemorrhage on base on aorta.

Scattered areas of consolidation on caudal lung lobes ( $\approx$ 40 % lung involvement).

2.5 to 3 cm hole in abomasal wall (about 7.5 cm from pyloric sphincter on lesser curvature of abomasum) - mesentery adhering to perforation (easily pulled apart).

Lining of abomasum very edematous and reddened - edema of submucosa.

Noted only a few strands of fibrin in peritoneal cavity.

Kidney Se 3,633 ng/g\*  
Cu 13 µg/g

Liver Se 678 ng/g  
Cu 107 µg/g

\* Tissue trace minerals are reported on a dry weight basis

## Toxicological Pathology Record Ranch A

AEC No. <b>940290</b>	Date of Necropsy 94.04.07			
Species Bovine	Breed Charolais X	Sex Male		
Age Stillborn	If found dead, estimated No. of Hours < 12 hours			
<b>History (Dam Bk 38)</b> Green "emissions" to the ground noted by the owner on April 5th and 6th 1994. Dam staggered at 06:00 and then started to calve. Local veterinarian did necropsy.				
<b>Gross Findings</b>  Samples taken by owner and placed in 10% buffered formalin: liver, kidney, spleen, lung, heart, thymus, trachea, mesenteric lymph node, intestine, skeletal muscle.				

## Toxicological Pathology Record Ranch A

AEC No. <b>940296</b>	Date of Necropsy 94.04.19			
Species Bovine	Breed Charolais X	Sex Male		
Age 8 weeks	If found dead, estimated No. of Hours Euthanyl Forte (iv)			
<p>History (Dam Gr 19 - on 93.12.06 Plasma Cu 565 ng/mL, Plasma Se 142 ng/mL, WBlood Se 254 ng/mL. Noticed right hind leg proprioceptive deficit on 94.02.15)  Calf born on 94.02.20.</p> <p>Illness on approximately February 26 or 27, 1994, which coincided with the owner's report of odors and the report from Shell of two more "hot spots" in river. Calf was depressed, hypothermic and anorectic (five calves died on February 27 to 28, 1994) and treated chronically with electrolytes, ampicillin (Polyflex® at 10 mg/lb bid) and Gentocin® or Amiglyde-V® (amikacin at 10 mg/lb bid), and Trimodox® (trimethoprin /sulfadoxine).</p> <p>Local veterinarian - blood sample on 94.03.10. I examined calf on 94.03.17 - crisp heart sounds, some harsh lung sounds in right lungs. Examined 94.04.15 - swollen right front knee and very stiff in movement.</p> <p>Calf appears to be sore on both front legs, knees swollen slightly and left stifle is swollen and hard with palpation. Poor prognosis given for survival.</p> <p>Birth weight 40.9 Kg.</p>				
<p><b>Gross Findings</b></p> <p>Weight 105 Kg</p> <p>No gross lesions observed in lungs.  Small "blood-filled cysts" on both atrioventricular valves.  Petechial hemorrhage on left epicardium.  Kidneys - bilateral petechial hemorrhage on surface.  Urinary bladder - emphysema of bladder wall.  Base of left femur shows erosion of articular cartilage (2.5-3 cm diam). Approximately 120 mL of a cloudy, reddish fluid aspirated from the joint cavity. Left popliteal lymph node enlarged.</p>				

Formalin tissue sections of kidney examined by avidin biotin complex immunoperoxidase were negative to *Leptospira*; sections of lymph node and brain were negative to both Bovine Herpes Virus Type 1 and Bovine Virus Diarrhea Virus but slightly positive to positive for *Listeria monocytogenes* (Diagnostic Immunology, WCVM, Saskatoon, SK).

### BACTERIOLOGY

The synovial fluid, which appeared to contain a lot of blood, was centrifuged and the stained smear confirmed this. No inflammatory cells or bacteria were seen and no growth was obtained on culture on blood agar (Palliser Animal Health Laboratories, LTD, Lethbridge, AB).

Kidney Se 3,377 ng/g*	Liver Se 1,587 ng/g
Cu 14 µg/g	Cu 190 µg/g

\* Tissue trace minerals are reported on a dry weight basis

## Toxicological Pathology Record Ranch A

AEC No. <b>940298</b>	Date of Necropsy 94.04.23	
Species Bovine	Breed Charolais X	Sex Male
Age 6 weeks	If found dead, estimated No. of Hours 1 - 5 hours	

### History (Dam Gr 161)

Chronic history of right knee infection. Treated with intra-articular Gentocin® in March. Given systemic treatment with ampicillin, tetracycline (long-acting). Joint was draining pus; in early April the open joint - frozen at a 45° angle - was treated with tincture of iodine and appeared to clear up.

Animal found dead in pasture.

### Gross Findings

Samples taken by owner and placed in 10% buffered formalin:

Liver, kidney, adrenal, spleen, heart, trachea, rumen, abomasum, intestinal section.

Owner described liver as pale, hemorrhage on heart valves and epicardium.

Abomasal ulcer ( 1 to 1.5 " in diameter) and peritoneal cavity contained gastrointestinal fluids.

## Toxicological Pathology Record Ranch A

AEC No. <b>940300</b>	Date of Necropsy 94.04.22	
Species Bovine	Breed Maine Anjou X	Sex Male - castrated
Age 12 days	If found dead, estimated No. of Hours 1 - 5 hours	

### History (Dam Bk 4)

94.04.18 appears very loose jointed (especially in stifle) in rear legs, rigid neck - gait problems; castrated on 94.04.18. 94.04.20 found in pasture with rapid, lateral eye movement (lateral nystagmus) and neck thrown back (opisthotonus) [VIDEO]. Owner treated with antibiotics, thiamine, B-complex). No improvement. Died 94.04.22.

### Gross Findings

Weight 114 Kg

Lungs: scattered areas of consolidation (redness) in all lung lobes (< 45% total lung involvement).

Heart: 8 to 10 mm fluid filled cyst on left atrioventricular valve

minute, small dark areas on right atrioventricular valve.

Blood tinged fluid ( $\pm$ 150-200 mL) in abdomen; clotted blood (10 cm diam) in mesentery and at the ends of spermatic cord.

Joints: right hip and stifle joints - normal in appearance; left tarsal joints - no gross lesions.

Brain - blood tinged fluid filled cyst ( $\pm$ 5 mL volume) on dorsal aspect of cerebellum. Approximately 10 mL of blood tinged fluid around brain.

Spinal cord (thoracic area) - no gross lesions.

Liver Se 1,121 ng/g\*

Cu 333  $\mu$ g/g

\* Tissue trace minerals are reported on a dry weight basis

## Toxicological Pathology Record Ranch A

AEC No. <b>940306</b>	Date of Necropsy 94.04.26			
Species Bovine	Breed Hereford X	Sex Male		
Age 3 days	If found dead, estimated No. of Hours ≈ 18 hours			
History (Dam Gr 23)				
Found dead - no clinical signs and no treatments.				
Gross Findings				
Weight 45 kg				
Good body condition - fat around kidney. Scattered areas of hemorrhage (redness) in all lung lobes (≈50 % total lung involvement). Marked hemorrhage on left atrioventricular valve and hemorrhage on right atrioventricular valve. About 4 to 5 mL of blood tinged fluid in pericardial sac.				
<b>BACTERIOLOGY</b> Cultures from liver, lung, spleen, and kidney. While there were contaminating colonies present there appeared to be a rich growth of mucoid beta hemolytic colonies of gram positive short rods. The organisms grew as well aerobically and anaerobically on blood agar and also grew, but poorly, on bile salt containing medium. The characters fit <i>A. pyogenes</i> which seems to have caused a septicemia rather than abscesses. There was no evidence of the streptococci or of salmonella (Palliser Animal Health Laboratories LTD, Lethbridge, AB).				
Kidney Se 3,578 ng/g*	Liver Se 2,632 ng/g			
Cu 10 µg/g	Cu 459 µg/g			
* Tissue trace minerals are reported on a dry weight basis				

## Toxicological Pathology Record Ranch A

AEC No. <b>940307</b>	Date of Necropsy 94.04.26	
Species Bovine	Breed Simmental-Saler X	Sex Female (twin to bull)
Age 7 weeks	If found dead, estimated No. of Hours Euthanyl Forte (iv)	

### History (Dam Gr 232)

Chronic history of arthritis - stiff and lame in left hind leg. 94.04.14 left stifle was swollen and hard. Animal had difficult mobility - poor prognosis.

### Gross Findings

Weight ≈ 100 Kg

Lungs: right and left lobes had two or three areas of adhesions to thoracic wall.

ventral portion of cardiac, apical, and caudal lobes had scattered abscesses of various diameters (5 to 15 mm) [45 % total lung involvement].

Heart: left ventricle shows ecchymotic hemorrhage of endocardium at papillary muscle.

Left stifle: ± 100 mL of a yellowish-green pus aspirated from joint, hypertrophy of joint capsule, bottom later condyle of femur - lime green; proximal tibia articular cartilage - lime green.

No evidence of ovaries or uterine horns.

Formalin tissue sections of liver examined by avidin biotin complex immunoperoxidase were negative to *Salmonella sp.* (Diagnostic Immunology, WCVM, Saskatoon, SK).

### BACTERIOLOGY

Culture of stifle swab showed growth on blood agar consisted of a variety of colonies but the predominant one had the same features as described for the growth obtained with #94-306 and must be considered *A. pyogenes*. Streptococci and salmonella were not detected (Palliser Animal Health Laboratories, LTD, Lethbridge, AB).

Kidney Se 3,514 ng/g\*  
Cu 23 µg/g

Liver Se 955 ng/g  
Cu 58 µg/g

Serum VE <0.25 µg/mL

\* Tissue trace minerals are reported on a dry weight basis

## Toxicological Pathology Record Ranch A

AEC No. <b>940370</b>	Date of Necropsy 94.05.25	
Species Bovine	Breed Simmental-Saler X	Sex Female
Age 12 days	If found dead, estimated No. of Hours < 24 hours	
History (Dam Yw 63)		
Found dead		
Gross Findings		
Samples taken by owner and placed in 10% buffered formalin: liver, kidney, spleen, lung, heart.		

## Toxicological Pathology Record Ranch B

AEC No. <b>940038</b>	Date of Necropsy 94.01.22																							
Species Bovine	Breed Red Angus	Sex Male																						
Age < 4 hours	If found dead, estimated No. of Hours > 24 hours																							
History (Dam #940040; on 94.01.21 Plasma Se 69 ng/mL, Plasma Cu 722 ng/mL) One of a set of twin bulls, both calves died soon after birth. Cow calved and cleaned without difficulty. Calf showed poor viability.																								
<b>Gross Findings</b> <p>Weight 30 Kg</p> <p>Normal component of fat around kidneys and in omentum.</p> <p>Lungs appear to contain fluid; not a normal pink color, interlobular spaces are very prominent. Lungs are dark, red to tan color, and have a glistening appearance. Lungs floated (&gt;50 % lung involvement).</p> <p>Prominently enlarged thyroid.</p> <p>Abomasum - some green material in stomach (ate something?); no colostrum.</p> <p>Mesenteric lymph nodes well developed.</p> <p>Spleen shows some petechiation/bruising.</p> <table> <tbody> <tr> <td>Liver</td> <td>678.5 g</td> <td></td> <td></td> </tr> <tr> <td>Heart</td> <td>307 g</td> <td></td> <td></td> </tr> <tr> <td>Left kidney</td> <td>46 g</td> <td>Right kidney</td> <td>42 g</td> </tr> <tr> <td>Brain</td> <td>273 g</td> <td>Spleen</td> <td>87.3 g</td> </tr> </tbody> </table> <p>Virus isolations and FA Tests for Infectious Bovine Rhinotracheitis and Bovine Virus Diarrhea were negative.</p> <table> <tbody> <tr> <td>Kidney Se 2,940 ng/g<sup>a</sup></td> <td>Liver Se 1220 ng/g</td> </tr> <tr> <td>Cu 14 µg/g</td> <td>Cu 539 µg/g</td> </tr> <tr> <td>Pb 697 ng/g</td> <td>Pb 1390 ng/g</td> </tr> </tbody> </table> <p><sup>a</sup> Tissue trace minerals are reported on a dry weight basis</p>			Liver	678.5 g			Heart	307 g			Left kidney	46 g	Right kidney	42 g	Brain	273 g	Spleen	87.3 g	Kidney Se 2,940 ng/g <sup>a</sup>	Liver Se 1220 ng/g	Cu 14 µg/g	Cu 539 µg/g	Pb 697 ng/g	Pb 1390 ng/g
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Pb 697 ng/g	Pb 1390 ng/g																							

Toxicological Pathology Record Ranch B

AEC No. <b>940039</b>	Date of Necropsy 94.01.22	
Species Bovine	Breed Red Angus	Sex Male
Age < 4 hours	If found dead, estimated No. of Hours > 24 hours	

History (Dam #940040 (#165); on 94.01.21 Plasma Se 69 ng/mL, Plasma Cu 722 ng/mL)  
One of a set of twin bulls. Cow calved and cleaned without difficulty.  
Calf showed poor viability.

Gross Findings

Weight 29 Kg

Normal component of fat.

Lungs appear to contain fluid; interlobular spaces are very prominent. Lungs are dark, red color, and have a glistening appearance. Lungs floated (> 50% lung involvement).

Bilateral enlargement of thyroid glands.

Abomasum - some green material in stomach (ate something?); no colostrum.

Mesenteric lymph nodes well developed.

Spleen shows some petechiation/bruising.

Liver 626 g

Heart 259 g

Left kidney 76 g Right kidney 72 g

Thyroid 54 g Spleen 89 g

Virus isolation and FA Tests for Infectious Bovine Rhinotracheitis and Bovine Virus Diarrhea were negative. Formalin tissue sections of spleen and lymph node examined by avidin biotin complex immunoperoxidase were negative to both Bovine Herpes Virus Type 1 and Bovine virus diarrhea virus (Diagnostic Immunology, WCVM, Saskatoon, SK).

Kidney Se 2,590 ng/g<sup>a</sup>

Cu 12.7 µg/g

Pb 809 ng/g

Liver Se 1,700 ng/g

Cu 247 µg/g

Pb 1250 ng/g

<sup>a</sup>Tissue trace minerals are reported on a dry weight basis

## Toxicological Pathology Record Ranch B

AEC No. <b>940119</b>	Date of Necropsy 94.02.22			
Species Bovine	Breed Red Angus	Sex Female		
Age ≈17 days	If found dead, estimated No. of Hours < 24 hours			
<p>History (Dam #940127 (# Blue 19) on 94.02.11: Plasma Cu 685 ng/mL, plasma Zn 816 ng/mL, plasma Se 62 ng/mL)</p> <p>Born 94.02.04 (27.3 Kg) hypothermic and calf taken to house, temperature dropped to 34°C; calf given colostrum, Synergistin® (ampicillin trihydrate and sulbactam benzathine), Trimodox®. Animal was kept in house to assist maintaining normal body temperature and given fluids. On 94.02.09 animal was examined: calf had some difficulty in mobility and appeared to have poor vision (menace response poor and calf walked right up to objects before stopping), but pupil light response normal. Blood taken for clinical pathology, animal given thiamin. Calf was kept in house until 94.02.10 and then placed in a box stall in the barn with the dam. Calf was assisted by owners in sucking cow but had visual difficulty. Calf died on 94.02.21. Serum T4 was 69 nmol/L, T3 was 2.0 nmol/L.</p>				
<p><b>Gross Findings</b></p> <p>Weight 27.7 Kg</p> <p>Hardly any body fat, pararenal fat virtually absent. No gross lesions in lungs. First free rib (right side) has a bony knob at the mid-rib area - perhaps a healing fracture? (sample taken). Pinpoint white foci in cortex of right prefemoral lymph node. Right inguinal lymph node enlarged (2.2 g) compared with left inguinal lymph node (0.8 g). Enlarged right popliteal lymph node (3.9 g) - wet and edematous appearance Left popliteal lymph node (2.9 g). Right area from tarsus to hock - reddened, wet - bruised appearance.</p> <p>Virus isolation and FA Tests for Infectious Bovine Rhinotracheitis and Bovine Virus Diarrhea were negative.</p> <p>Kidney Se 2,880 ng/g<sup>a</sup>      Liver Se 4,950 ng/g  Cu 24.5 µg/g      Cu 280 µg/g</p> <p><sup>a</sup> Tissue trace minerals are reported on a dry weight basis</p>				

## Toxicological Pathology Record Ranch B

AEC No. <b>940135</b>	Date of Necropsy 94.02.16			
Species Bovine	Breed Red Angus	Sex Female		
Age Stillborn	If found dead, estimated No. of Hours > 24 hours			
History (Dam # 1)				
Gross Findings				
Weight 37.3 Kg. Autolytic. Normal component of body fat. Lungs were a solid red color - did not float in water.				
Virus isolation and FA Tests for Infectious Bovine Rhinotracheitis and Bovine Virus Diarrhea were negative.				
Kidney Se 1,870 ng/g <sup>a</sup> Cu 14 µg/g	Liver Se 2,880 ng/g Cu 294 µg/g			
<sup>a</sup> Tissue trace minerals are reported on a dry weight basis				

Toxicological Pathology Record Ranch B

AEC No. <b>940136</b>	Date of Necropsy 94.02.16	
Species Bovine	Breed Red Angus	Sex Female (twin to bull)
Age 14 days	If found dead, estimated No. of Hours Moribund - exsanguinated	

History (Dam # 98)

Birth weight 27.3 Kg [bull twin 31.4 Kg].

Female calf was born towards the end of a warm spell and in a heated barn, but temperature of calf dropped to 35.7°C within 30 minutes. Calf taken to the house to warm up. A calf from cow #98 (most probably this calf as it was the smaller of the twins - AEC # 940122) was bled on 94.02.10 for normal clinical pathology values in calves in this herd - both twins appeared normal. Later this calf developed a diarrhea and was treated with gentamycin and fluids. Calf became moribund - comatose; poor prognosis. Blood sample taken for clinical pathology.

Gross Findings

Weight 36.7 Kg.

Perineal area shows evidence of a diarrhea.

Red color, consolidation of right lung - ventral aspect of cardiac and caudal lobes (<45 % lung involvement).

Prominent enlargement of thyroid glands.

Milk curd in stomach.

Virus isolation and FA Tests for Infectious Bovine Rhinotracheitis and Bovine Virus Diarrhea were negative. Formalin tissue sections of small and large intestine examined by avidin biotin complex immunoperoxidase were negative to both Bovine coronavirus and rotavirus (Diagnostic Immunology, WCVM, Saskatoon, SK).

Kidney Se 3,670 ng/g <sup>a</sup>	Liver Se 8,640 ng/g
Cu 18 µg/g	Cu 524 µg/g

<sup>a</sup> Tissue trace minerals are reported on a dry weight basis

Toxicological Pathology Record Ranch B

AEC No. <b>940137</b>	Date of Necropsy 94.02.22	
Species Bovine	Breed Red Angus	Sex Male (twin to bull)
Age 7 days	If found dead, estimated No. of Hours	
History (Dam # 46B) Birth weight 25.4 Kg [bull twin 24.5 Kg]. Blood sample taken for clinical pathology.		
Gross Findings  Weight 31.8 Kg. Small (1 to 1.5 mm in diameter) hemorrhages scattered though out all lung lobes. Ecchymotic hemorrhage of ventral aspect of left lobe (100 % lung involvement). Little body fat.		
Virus isolation and FA Tests for Infectious Bovine Rhinotracheitis and Bovine Virus Diarrhea were negative. Formalin tissue sections of small and large intestine examined by avidin biotin complex immunoperoxidase showed a positive to Bovine coronavirus and a negative to rotavirus (Diagnostic Immunology, WCVM, Saskatoon, SK).		
Kidney Se 4,970 ng/g <sup>a</sup> Cu 19 µg/g                      Liver Se 16 µg/g Cu 502 µg/g		

<sup>a</sup> Tissue trace minerals are reported on a dry weight basis

## Toxicological Pathology Record Ranch B

AEC No. <b>940237</b>	Date of Necropsy 94.03.18			
Species Bovine	Breed Red Angus	Sex Female (twin to bull)		
Age 4 weeks	If found dead, estimated No. of Hours Electrocution			
History (Dam # 2B) Birth weight 39 Kg. [bull twin 35.4 Kg - See AFC No. 940249]. Bilateral sloughing of hind feet below dewclaws - poor prognosis. Blood sample taken for clinical pathology.				
<b>Gross Findings</b>  Weight 47.7 Kg. Small (1 to 1.5 mm in diameter) hemorrhages scattered though out all lung lobes. Ecchymotic hemorrhage of ventral aspect of left apical lobe (100 % lung involvement). Little body fat. Bilateral sloughing of hind feet below dewclaws - area is necrotic - detachment at joints.				
Kidney Se 2,550 ng/g <sup>a</sup> Cu 16 µg/g                         Liver Se 3,770 ng/g Cu 121 µg/g				
<sup>a</sup> Tissue trace minerals are reported on a dry weight basis				

Toxicological Pathology Record Ranch B

AEC No. <b>940238</b>	Date of Necropsy 94.03.18			
Species Bovine	Breed Red Angus	Sex Female		
Age 3 weeks	If found dead, estimated No. of Hours Electrocution			
<p>History (Dam # 8B)</p> <p>Birth weight 40.4 Kg. [Born in a cattle shed; outdoor temperature range from -19 to -35°C].</p> <p>Bilateral sloughing of hind feet below dewclaws, loss of right front foot below dewclaw - poor prognosis.</p> <p>Calf was gaunt in appearance.</p> <p>Blood sample taken for clinical pathology. T4 14 nmol/L, T3 0.89 nmol/L.</p>				
<p>Gross Findings</p> <p>Weight 35.4 Kg.</p> <p>Little body fat.</p> <p>Bilateral pattern of scattered areas of consolidation in apical and cardiac lung lobes (&lt; 30% total lung involvement).</p> <p>Ecchymotic hemorrhage on right atrioventricle valve.</p> <p>Necrotic tissue on right front leg below dewclaw.</p> <p>Bilateral sloughing of hind feet below dewclaw - area necrotic with pus.</p>				
<p>Kidney Se 3,250 ng/g<sup>a</sup> Cu 25.7 µg/g</p> <p>Liver Se 1,540 ng/g Cu 107 µg/g</p>				
<p><sup>a</sup> Tissue trace minerals are reported on a dry weight basis</p>				

## Toxicological Pathology Record Ranch B

AEC No. <b>940249</b>	Date of Necropsy 94.03.30			
Species Bovine	Breed Red Angus	Sex Male (twin to female)		
Age 5 weeks	If found dead, estimated No. of Hours Euthanyl Forte (iv)			
History (Dam # 2B - see AEC #940237) Birth weight 35.4 Kg. Bilateral sloughing of hind feet below dewclaws, epidermis over right carpal area is hard - perhaps was frozen.				
<b>Gross Findings</b>  Weight ≈ 56.8 Kg. Good body condition. No gross lesions in lungs. No involvement of right carpal joint. Bilateral sloughing of hind feet below dewclaws - area necrotic.				
Kidney Se 4,130 ng/g Cu 13.5 µg/g	Liver Se 2,470 ng/g Cu 179 µg/g Fe 171 µg/g			

## Toxicological Pathology Record Ranch B

AEC No. <b>940250</b>	Date of Necropsy 94.03.30			
Species Bovine	Breed Red Angus	Sex Male		
Age 6 weeks	If found dead, estimated No. of Hours Euthanyl Forte (iv)			
History (Dam # 195) Birth weight 40.9 Kg. Sloughing left hind foot below dewclaws and lost right hind foot below fetlock (necrotic tissue).				
<b>Gross Findings</b>  Weight ≈ 41 Kg. Poor body condition - little evidence of fat. Scattered red consolidation on ventral aspects of right and left lung lobes (< 30 % total lung involvement). Necrotic tissue on right hind leg below fetlock. Sloughing and necrosis of left hind foot below dewclaw. No involvement of right carpal joint. Bilateral sloughing of hind feet below dewclaws - area necrotic.				
Kidney Se 2,650 ng/g Cu 13.6 µg/g	Liver Se 1,400 ng/g Cu 64 µg/g Fe 104 µg/g			

## Toxicological Pathology Record Ranch B

AEC No. <b>940278</b>	Date of Necropsy 94.05.31	
Species Bovine	Breed Red Angus	Sex Male
Age 2 years	If found dead, estimated No. of Hours Euthanyl Forte (iv)	

### History

Acute onset of weight loss and pneumonia (diagnosed by local veterinarians) about two months ago. Animal treated with Mycotil® (Tilmicosin) and Tylocine - animal continued to lose weight. Exhibited pronounced jugular pulse, loose fecal material and marked cachexia (even though animal is eating) on examination about two weeks prior to necropsy - poor prognosis. Bull carried testicles retracted against body wall.

### Gross Findings

Weight ≈ 443Kg.

Lungs: lobular pattern of consolidation/redness - especially ventral portion of right caudal lobe and ventral apical and cardiac lobes (≈30 % total lung involvement). [photo]

Heart: weighed about 2.6 Kg - right atrium - ecchymotic hemorrhages on epicardium.

right coronary sulcus - hemorrhage

(vegetative endocarditis) - ≈7 cm in diameter with attachment to right atrioventricular valve - four separate growths (culture swab, photo)

Poor body condition - little evidence of fat.

Kidneys - no gross lesions (very little fat around kidneys)

Spleen - no gross lesions

Liver - no gross lesions

Rumen - grass contents, no gross lesions.

Reticulum - no gross lesions

Abomasum - several areas ( 2.5 X 5 cm of edema and hemorrhage of mucosa near pyloric sphincter)

Testes - no gross lesions (32 cm on scrotal tape measurement prior to euthanasia)

### BACTERIOLOGY

Cut surfaces of pieces of lung and A/V valve were dabbed, and swab was streaked on plates of Columbia blood agar and incubated aerobically for 24 hours. A few scattered colonies of *Staphylococcus aureus* appeared with no sign of other growth. The plates were re-incubated anaerobically for another 24 hours. The lung impressions then showed in addition to the earlier observed staphylococcal colonies many pinpoint translucent colonies of gram positive, very pleomorphic colonies diagnosed on their appearance as *Actinomyces pyogenes*. Very heavy growths were seen on both the swab and A/V valve inoculated plates of translucent clean edged colonies of size varying from 0.5 to 1.0 mm diameter of gram negative coccobacilli in clumps and chains diagnosed as *Hemophilus somnus* (Palliser Animal Health Laboratories, LTD, Lethbridge, AB).

Plasma VE <0.25 µg/mL

Kidney Se 4,280 ng/g	Liver Se 925 ng/g	Se 68 ng/mL
Cu 54 µg/g	Cu 227 µg/g	Cu 633 ng/mL
Cd 1,530 ng/g	Fe 217 µg/g	Zn 2,040 ng/mL

Blood Se 143 ng/mL

### Toxicological Pathology Record Ranch B

AEC No. <b>940279</b>	Date of Necropsy 94.04.27			
Species Bovine	Breed Red Angus	Sex Female		
Age 7 weeks	If found dead, estimated No. of Hours ≈ 12 hours			
History (Dam # 23 B)				
Noticed lethargic at noon; dead at 13:30. Necropsy by local veterinarian who according to the owner observed an occluded abomasum at pyloric opening.				
Gross Findings Samples taken by owner at time of necropsy.				

## Toxicological Pathology Record Ranch B

AEC No. <b>940287</b>	Date of Necropsy 94.05.04			
Species Bovine	Breed Red Angus	Sex Female		
Age 8 weeks	If found dead, estimated No. of Hours ≈ 18 hours			
History (Dam # 170) On 94.06.01 owner observed calf as being lethargic with pale mucous membrane color. Treated animal with electrolytes and antibiotic (Tylocine); animal anorectic. Found animal dead on 94.05.04.				
<b>Gross Findings</b>				
Weight ≈ 102 Kg.				
No evidence of diarrhea. Good body condition - normal amount of body fat. Lungs: bilateral lobular hemorrhage pattern affecting all lung lobes (appears as hemorrhage of terminal bronchioles) Scattered lobules showing consolidation (2.5 to 5 cm affected in the pattern) (100 % lung involvement). Heart - no gross lesions. Rumen - presence of a small amount of hay. Abomasum - 3 to 4 cm trichobezoar and additional hair/hay in abomasum - no visual evidence of wall thickening or erosions. Kidneys - bilateral pattern of scattered white round (5 mm diam) foci on surface and interior of kidneys. Liver - no gross lesions. Brain - no gross lesions.				
Kidney Se 4,370 ng/g      Liver Se 1,880 ng/g Cu 15 µg/g      Cu 354 µg/g				

## Toxicological Pathology Record Ranch B

AEC No. <b>940299</b>	Date of Necropsy 94.04.22			
Species Bovine	Breed Red Angus	Sex Female		
Age 13 years	If found dead, estimated No. of Hours Euthanyl Forte (iv)			
<b>History</b> 94.04.20 Found in pasture wandering in circles; tongue out on left side, left side paresis, no pain evident in left face, inability to swallow. (Local veterinarian observed animal). 94.04.22 Cow was not eating, difficulty drinking - tipped water bucket over when trying to drink. Temperature 39°C, no rumen motility, no harsh lung sounds. No corneal blink reflex in left eye (ulcer present on left cornea); cow feels pain (needle prick) in left face, left ear down, some retraction of tongue into mouth. Blood taken for clinical pathology, but not evaluated because the differential diagnosis included rabies.				
<b>Gross Findings</b> Lungs: emphysema of all lobes and mediastinum, but particularly caudal lung lobes. Heart: left and right ventricle - endocardial hemorrhage over papillary muscle. Uterus: small amount of fluid. Ovary - follicle on one ovary. Rumen - dry contents, removed one wheelbarrow full of hay from rumen. Cerebrospinal fluid - blood tinged. Appearance of corneal ulcer on left eye.  Rabies: FA negative on 94.04.28 call from Agriculture Canada, Vermilion.  No microbiology performed because of a differential diagnosis of rabies.				
Kidney Se 5,080 ng/g Cu 18 µg/g	Liver Se 1,190 ng/g Cu 87 µg/g	Plasma Se 119 ng/mL Cu 1,460 ng/mL Zn 608 ng/mL VE <0.25 µg/mL Blood Se 230 ng/mL		

## Toxicological Pathology Record Ranch B

AEC No. <b>940308</b>	Date of Necropsy 94.04.25	
Species Bovine	Breed Red Angus	Sex Male
Age 10 weeks	If found dead, estimated No. of Hours ≈ 1 to 5 hours	

### History (Dam # 123)

Born 94.02.09 (weight 39 Kg); found at 01:30 with uncontrollable functions according to the owners - taken to house. At 03:00 - no temperature registered on thermometer, at 06:30 the temperature was 33.5°C (had been under a hair dryer all the time in the house). Calf held head back, neck stretched out, bawling, uncontrolled leg movements. At 07:30, the temperature was 35.9°C and calf shivering. (Cow normally a good mother showed little interest in calf).

At one month of age, calf was grinding teeth and had an elevated temperature. Treated with Trimodox®/ penicillin for 5 days.

For several weeks prior to death the owner reported the breath smelled bad.

### Gross Findings

Samples taken by owner at time of necropsy.

Lungs - 100 % involvement - very bad odor, abscesses.

Formalin tissue section of lung examined by avidin biotin complex immunoperoxidase was positive to *Hemophilus somnus* and negative to *Pasteurella hemolytica* (Diagnostic Immunology, WCVM, Saskatoon, SK).

Toxicological Pathology Record Ranch B

AEC No. <b>940309</b>	Date of Necropsy 94.04.05			
Species Bovine	Breed Red Angus	Sex Female		
Age 12 weeks	If found dead, estimated No. of Hours ≈ 12 hours			
<p>History (Dam # 120)</p> <p>History of a green gas coming into the cattle yard and cattle pasture.</p> <p>Postmortem by local veterinarian.</p> <p>According to the owner, the calf had a diarrhea - bloody, concerned about coccidiosis.</p> <p>I observed calf on 94.04.05 - calf was dehydrated.</p>				
<p>Gross Findings</p> <p>Samples taken by owner at time of necropsy.</p>				

## Toxicological Pathology Record Ranch B

AEC No. <b>940367</b>	Date of Necropsy 94.05.?	
Species Bovine	Breed Red Angus	Sex Bull
Age ≈ 8 weeks	If found dead, estimated No. of Hours <24 hours	
<p>History (Dam # 174) Born 94.03.10 (43.2 Kg). Treated with electrolytes, Trimodox®/penicillin for 5 days when young - never improved. Poor doing calf.</p>		
<p>Gross Findings Samples taken by owner at time of necropsy. Lungs - evidence of pneumonia (estimated 50% involvement). Lesions in heart (hemorrhage).</p>		

Toxicological Pathology Record Ranch B

AEC No. <b>950127</b>	Date of Necropsy 95.06.03	
Species Bovine	Breed Red Angus	Sex Female
Age ≈8 years	If found dead, estimated No. of Hours Euthanized by gunshot to head (.22); 0.75 mL Rompun (iv)	

History (BT White # 98)

1994 -- according to owner, cow appeared to have respiratory difficulty (pneumonia). 1995 -- cow showed deterioration in physical condition. Cow calved on 95.03.16, delivering a live heifer calf. According to the owners, following calving the cow became gaunt, developed swelling in the cranoventral thoracic area, and showed marked lethargy.

95.06.03: Cow was cachectic with marked ventral edema, jugular pulse, mouth breathing, depression, and became recumbent when forced to move.

Gross Findings

Weight 604.5 Kg

Animal had massive ventral edema . Approximately five gallons of a light-yellow tinged fluid in pleural cavity.

Right lung edematous with about 75% involvement - dorsal aspect of apical right lung, almost all of cardiac lobe involved.

Left lung edematous with about 15% involvement - ventral aspect of cardiac lobe. Increased redness and firmness of the lungs (Photos taken)

Heart - enlarged and flabby.

Left kidney - cortical cysts

Right kidney - capsule peeled easily, scars on surface of kidney extending down into medulla (section taken and Photo). Right kidney has a kidney stone.

Spleen is slightly swollen, hemorrhagic along mesenteric attachment.

Gall bladder is edematous.

Liver is slightly swollen, firm to almost tough in palpation with a mottled appearance. Distinct tan and white colored appearance, white spot on the cut surface (?fibrous tissue or fibrotic areas).

Brain -- darkening on frontal lobe of cerebrum (Photos). Located .22. in cranium.

Bacteriology: Lung section submitted to Palliser Animal Health Laboratories, LTD., Lethbridge, AB which reported isolation of *Corynebacterium xerosis* (Provincial Laboratory, Calgary, AB identification). Verification by Dept. Microbiology, Western College of Veterinary Medicine, Saskatoon, SK.

Trace Nutrient Status (95.06.03):

Whole Blood Selenium 243 ng/mL

Plasma Selenium 104 ng/mL

Plasma Copper 964 ng/mL

Plasma Zinc 1353 ng/mL

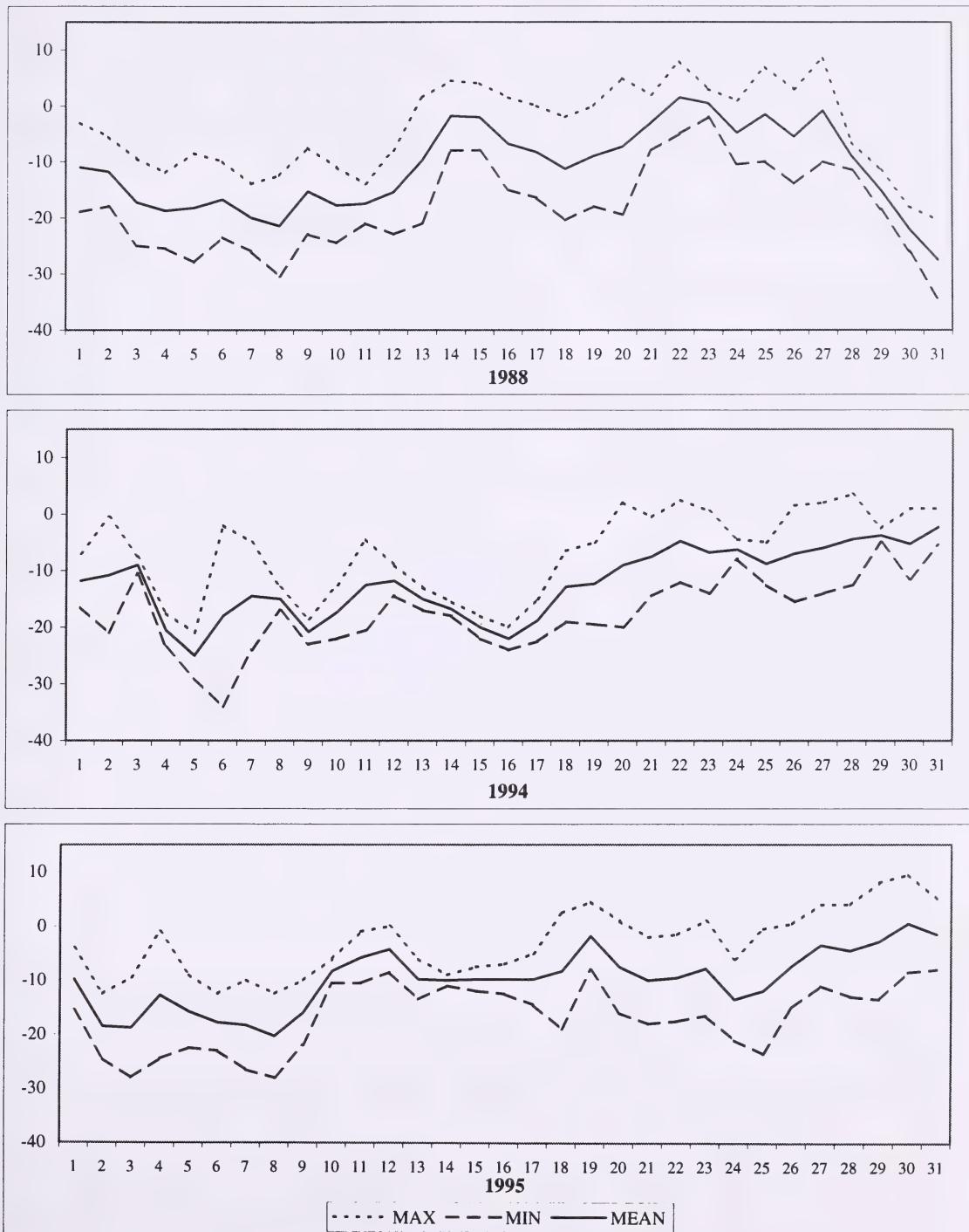


## **APPENDIX C**

**WEATHER FOR THE SUNDRE AREA FOR 1994, 1995, AND 1998**



## Sundre Weather for January



Temperatures on the Y axis are in degrees Celsius

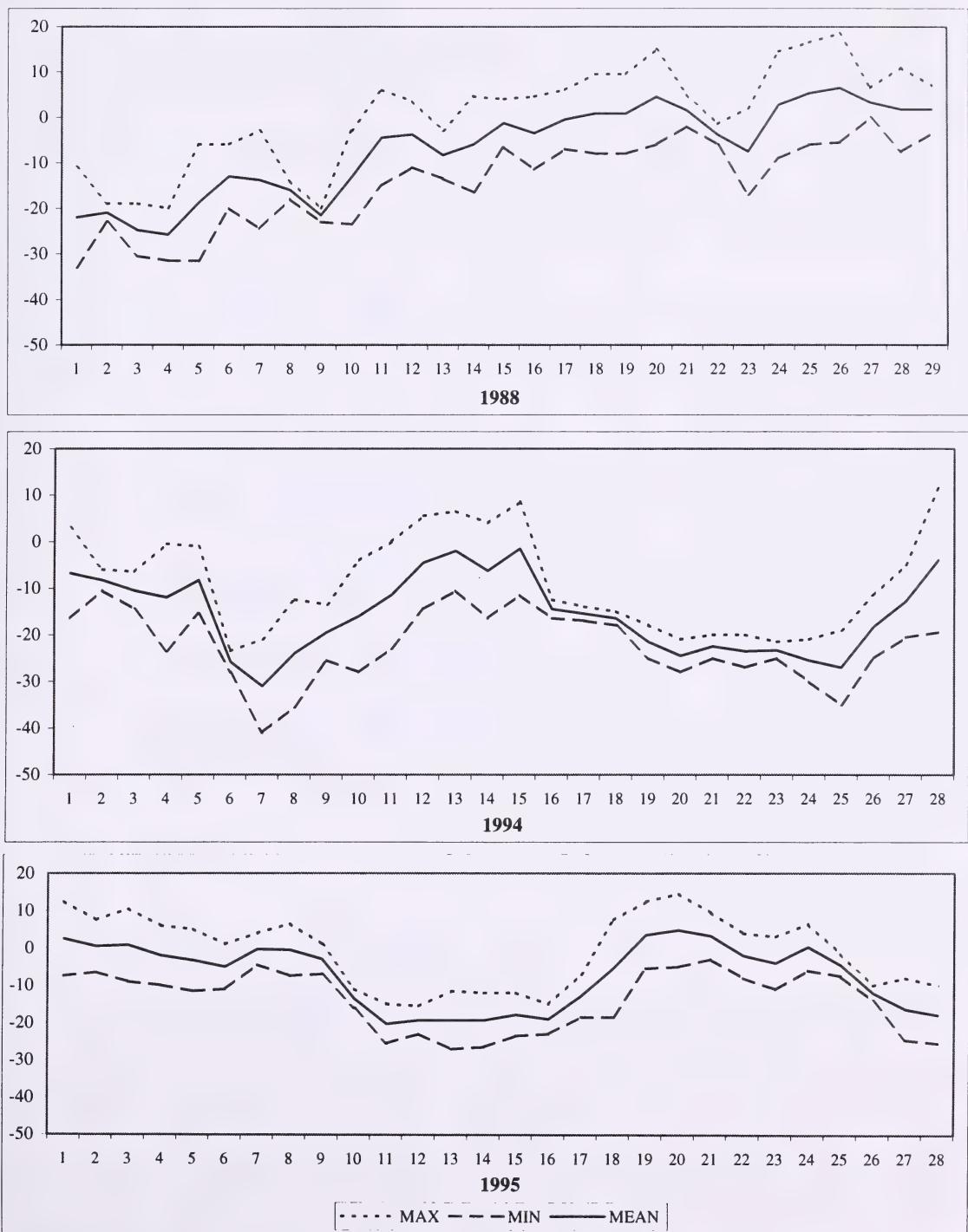
## January Weather Data for Sundre

DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>	DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>	DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>
1/1/88	-3.0	-19.0	-11.0		1/1/94	-7.0	-16.5	-11.8	4.0	1/1/95	-4.0	-15.5	-9.8	
1/2/88	-5.5	-18.0	-11.8		1/2/94	-0.5	-21.0	-10.8		1/2/95	-12.5	-24.5	-18.5	
1/3/88	-9.5	-25.0	-17.3		1/3/94	-7.5	-10.5	-9.0	8.0	1/3/95	-9.5	-28.0	-18.8	
1/4/88	-12.0	-25.5	-18.8		1/4/94	-17.5	-23.5	-20.5	T	1/4/95	-1.0	-24.5	-12.8	
1/5/88	-8.5	-28.0	-18.3	T	1/5/94	-21.0	-29.0	-25.0	T	1/5/95	-9.0	-22.5	-15.8	T
1/6/88	-10.0	-23.5	-16.8	T	1/6/94	-2.0	-34.0	-18.0	T	1/6/95	-12.5	-23.0	-17.8	T
1/7/88	-14.0	-26.0	-20.0		1/7/94	-5.0	-24.0	-14.5	0.6	1/7/95	-10.0	-26.5	-18.3	
1/8/88	-12.5	-30.5	-21.5		1/8/94	-13.0	-17.0	-15.0		1/8/95	-12.5	-28.0	-20.3	
1/9/88	-7.5	-23.0	-15.3		1/9/94	-18.5	-23.0	-20.8	T	1/9/95	-10.0	-22.0	-16.0	
1/10/88	-11.0	-24.5	-17.8	T	1/10/94	-12.5	-22.0	-17.3		1/10/95	-6.0	-10.5	-8.3	5.0
1/11/88	-14.0	-21.0	-17.5	1.0	1/11/94	-4.5	-20.5	-12.5	T	1/11/95	-1.0	-10.5	-5.8	
1/12/88	-8.0	-23.0	-15.5		1/12/94	-9.0	-14.5	-11.8	T	1/12/95	0.0	-8.5	-4.3	
1/13/88	1.5	-21.0	-9.8		1/13/94	-13.0	-17.0	-15.0	8.0	1/13/95	-6.0	-13.5	-9.8	T
1/14/88	4.5	-8.0	-1.8		1/14/94	-15.5	-18.0	-16.8	1.0	1/14/95	-9.0	-11.0	-10.0	T
1/15/88	4.0	-8.0	-2.0		1/15/94	-18.0	-22.0	-20.0	3.0	1/15/95	-7.5	-12.0	-9.8	2.0
1/16/88	1.5	-15.0	-6.8		1/16/94	-20.0	-24.0	-22.0	4.0	1/16/95	-7.0	-12.5	-9.8	1.0
1/17/88	0.0	-16.5	-8.3		1/17/94	-15.0	-22.5	-18.8	3.0	1/17/95	-5.0	-14.5	-9.8	
1/18/88	-2.0	-20.5	-11.3		1/18/94	-6.5	-19.0	-12.8	T	1/18/95	2.5	-19.0	-8.3	
1/19/88	0.0	-18.0	-9.0		1/19/94	-5.0	-19.5	-12.3		1/19/95	4.5	-8.0	-1.8	
1/20/88	5.0	-19.5	-7.3		1/20/94	2.0	-20.0	-9.0		1/20/95	1.0	-16.0	-7.5	
1/21/88	2.0	-8.0	-3.0		1/21/94	-0.5	-14.5	-7.5		1/21/95	-2.0	-18.0	-10.0	
1/22/88	8.0	-5.0	1.5		1/22/94	2.5	-12.0	-4.8		1/22/95	-1.5	-17.5	-9.5	
1/23/88	3.0	-2.0	0.5		1/23/94	0.5	-14.0	-6.8	T	1/23/95	1.0	-16.5	-7.8	
1/24/88	1.0	-10.5	-4.8		1/24/94	-4.5	-8.0	-6.3	1.0	1/24/95	-6.0	-21.0	-13.5	
1/25/88	7.0	-10.0	-1.5		1/25/94	-5.0	-12.5	-8.8		1/25/95	-0.5	-23.5	-12.0	
1/26/88	3.0	-14.0	-5.5		1/26/94	1.5	-15.5	-7.0	T	1/26/95	0.5	-15.0	-7.3	
1/27/88	8.5	-10.0	-0.8	T	1/27/94	2.0	-14.0	-6.0		1/27/95	4.0	-11.0	-3.5	
1/28/88	-6.5	-11.5	-9.0	T	1/28/94	3.5	-12.5	-4.5		1/28/95	4.0	-13.0	-4.5	
1/29/88	-11.5	-18.5	-15.0	2.0	1/29/94	-2.5	-5.0	-3.8	2.0	1/29/95	8.0	-13.5	-2.8	
1/30/88	-18.0	-26.0	-22.0		1/30/94	1.0	-11.5	-5.3	T	1/30/95	9.5	-8.5	0.5	
1/31/88	-20.5	-34.5	-27.5		1/31/94	1.0	-5.5	-2.3		1/31/95	5.0	-8.0	-1.5	T

<sup>a</sup>Degrees Celsius

<sup>b</sup>Snow in centimeters, rain in millimeters. Check temperatures to determine type of precipitation

### Sundre Weather for February



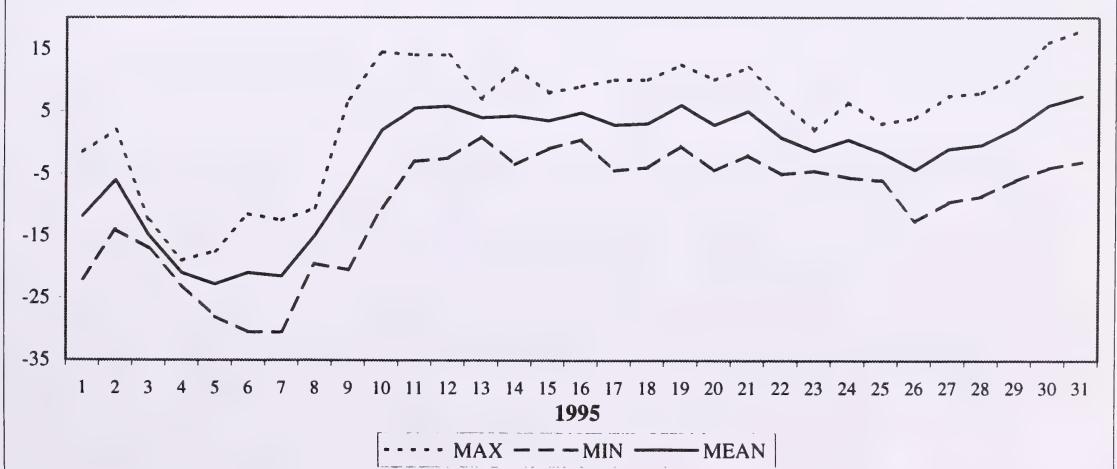
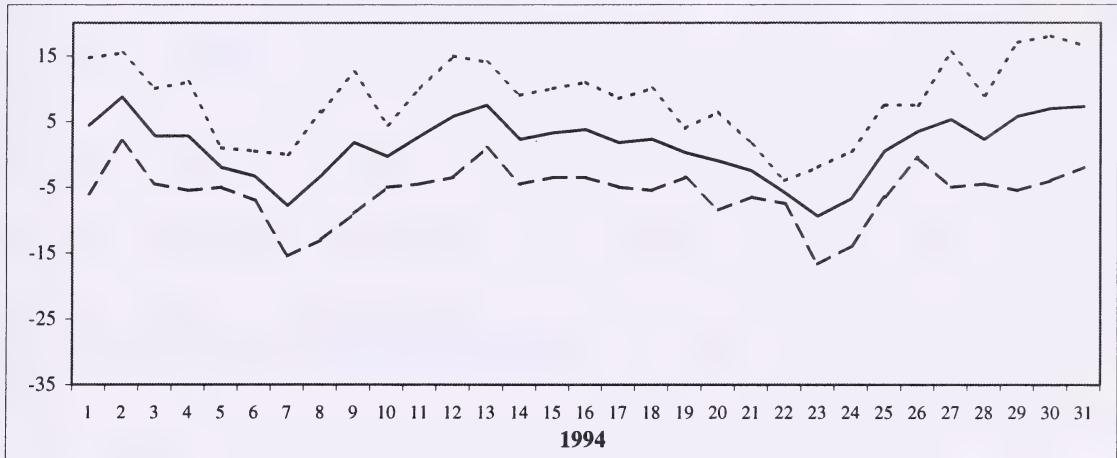
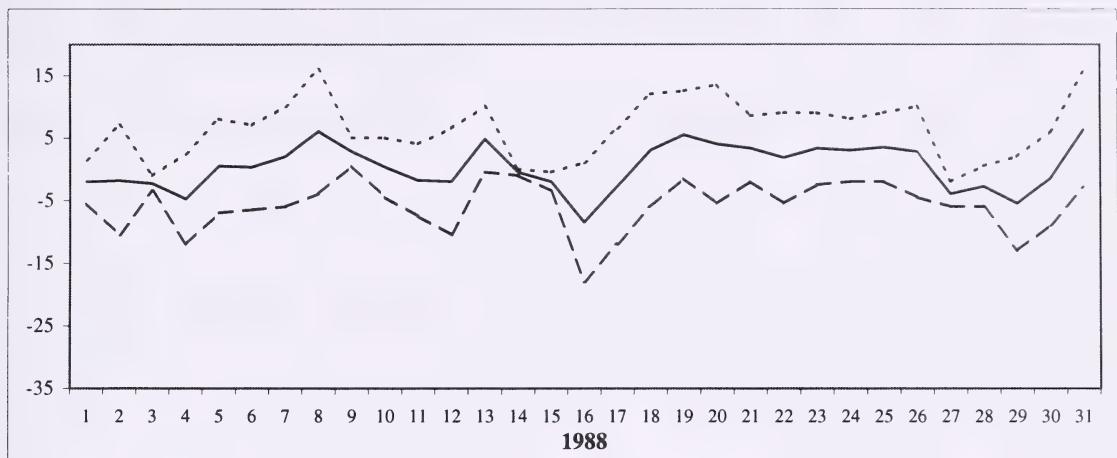
Temperatures on the Y axis are in degrees Celsius

## February Weather Data for Sundre

	DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>	DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>	DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>
2/1/88	-11.0	-33.0	-22.0	2/1/94	3.0	-16.5	-6.8	1.0	2/1/95	12.5	-7.5	2.5			
2/2/88	-19.0	-23.0	-21.0	2/2/94	-6.0	-10.5	-8.3	3.0	2/2/95	7.5	-6.5	0.5			
2/3/88	-19.0	-30.5	-24.8	2/3/94	6.5	-14.5	-10.5	T	2/3/95	10.5	-9.0	0.8			
2/4/88	-20.0	-31.5	-25.8	1.0	2/4/94	-0.5	-23.5	-12.0		2/4/95	6.0	-10.0	-2.0		
2/5/88	-6.0	-31.5	-18.8		2/5/94	-1.0	-15.5	-8.3	7.5	2/5/95	5.0	-11.5	-3.3		
2/6/88	-6.0	-20.0	-13.0	1.0	2/6/94	-23.5	-28.0	-25.8		2/6/95	1.0	-11.0	-5.0		
2/7/88	-3.0	-24.5	-13.8	4.0	2/7/94	-21.0	-41.0	-31.0		2/7/95	4.0	-4.5	-0.3	0.4	T
2/8/88	-14.0	-18.0	-16.0	3.0	2/8/94	-12.5	-35.5	-24.0		2/8/95	6.5	-7.5	-0.5		
2/9/88	-20.0	-23.0	-21.5	1.0	2/9/94	-13.5	-25.5	-19.5		2/9/95	1.0	-7.0	-3.0		
2/10/88	-3.0	-23.5	-13.3		2/10/94	-4.0	-28.0	-16.0		2/10/95	-11.0	-16.0	-13.5		
2/11/88	6.0	-15.0	-4.5		2/11/94	0.0	-23.0	-11.5		2/11/95	-15.0	-25.5	-20.3		
2/12/88	3.5	-11.0	-3.8		2/12/94	5.5	-14.5	-4.5		2/12/95	-15.5	-23.0	-19.3		
2/13/88	-3.0	-13.5	-8.3		2/13/94	6.5	-10.5	-2.0		2/13/95	-11.5	-27.0	-19.3		
2/14/88	4.5	-16.5	-6.0		2/14/94	4.0	-16.5	-6.3		2/14/95	-12.0	-26.5	-19.3		
2/15/88	4.0	-6.5	-1.3		2/15/94	8.5	-11.5	-1.5		2/15/95	-12.0	-23.5	-17.8	T	
2/16/88	4.5	-11.5	-3.5		2/16/94	-12.5	-16.5	-14.5	T	2/16/95	-15.0	-23.0	-19.0	T	
2/17/88	6.0	-7.0	-0.5		2/17/94	-14.0	-17.0	-15.5	T	2/17/95	-7.0	-18.5	-12.8		
2/18/88	9.5	-8.0	0.8		2/18/94	-15.0	-18.0	-16.5	T	2/18/95	7.5	-18.5	-5.5		
2/19/88	9.5	-8.0	0.8		2/19/94	-18.0	-25.0	-21.5	0.4	2/19/95	12.5	-5.5	3.5		
2/20/88	15.0	-6.0	4.5		2/20/94	-21.0	-28.0	-24.5	T	2/20/95	14.5	-5.0	4.8		
2/21/88	5.0	-2.0	1.5		2/21/94	-20.0	-25.0	-22.5	0.5	2/21/95	9.5	-3.0	3.3		
2/22/88	-1.5	-6.0	-3.8		2/22/94	-20.0	-27.0	-23.5	T	2/22/95	4.0	-8.0	-2.0		
2/23/88	2.0	-17.0	-7.5		2/23/94	-21.5	-25.0	-23.3	0.4	2/23/95	3.0	-11.0	-4.0		
2/24/88	14.5	-9.0	2.8		2/24/94	-21.0	-30.0	-25.5		2/24/95	6.5	-6.0	0.3		
2/25/88	16.5	-6.0	5.3		2/25/94	-19.0	-35.0	-27.0		2/25/95	-1.5	-7.5	-4.5	0.4	
2/26/88	18.5	-5.5	6.5		2/26/94	-11.5	-25.0	-18.3		2/26/95	-10.0	-14.0	-12.0	3.6	T
2/27/88	6.5	0.0	3.3	1.0	2/27/94	-5.0	-20.5	-12.8		2/27/95	-8.0	-24.5	-16.3		
2/28/88	11.0	-7.5	1.8		2/28/94	11.5	-19.5	-4.0		2/28/95	-10.0	-25.5	-17.8		
2/29/88	7.0	-3.5	1.8												

<sup>a</sup>Degrees Celsius<sup>b</sup>Snow in centimeters, rain in millimeters. Check temperatures to determine type of precipitation

## Sundre Weather for March



Temperatures on the Y axis are in degrees Celsius

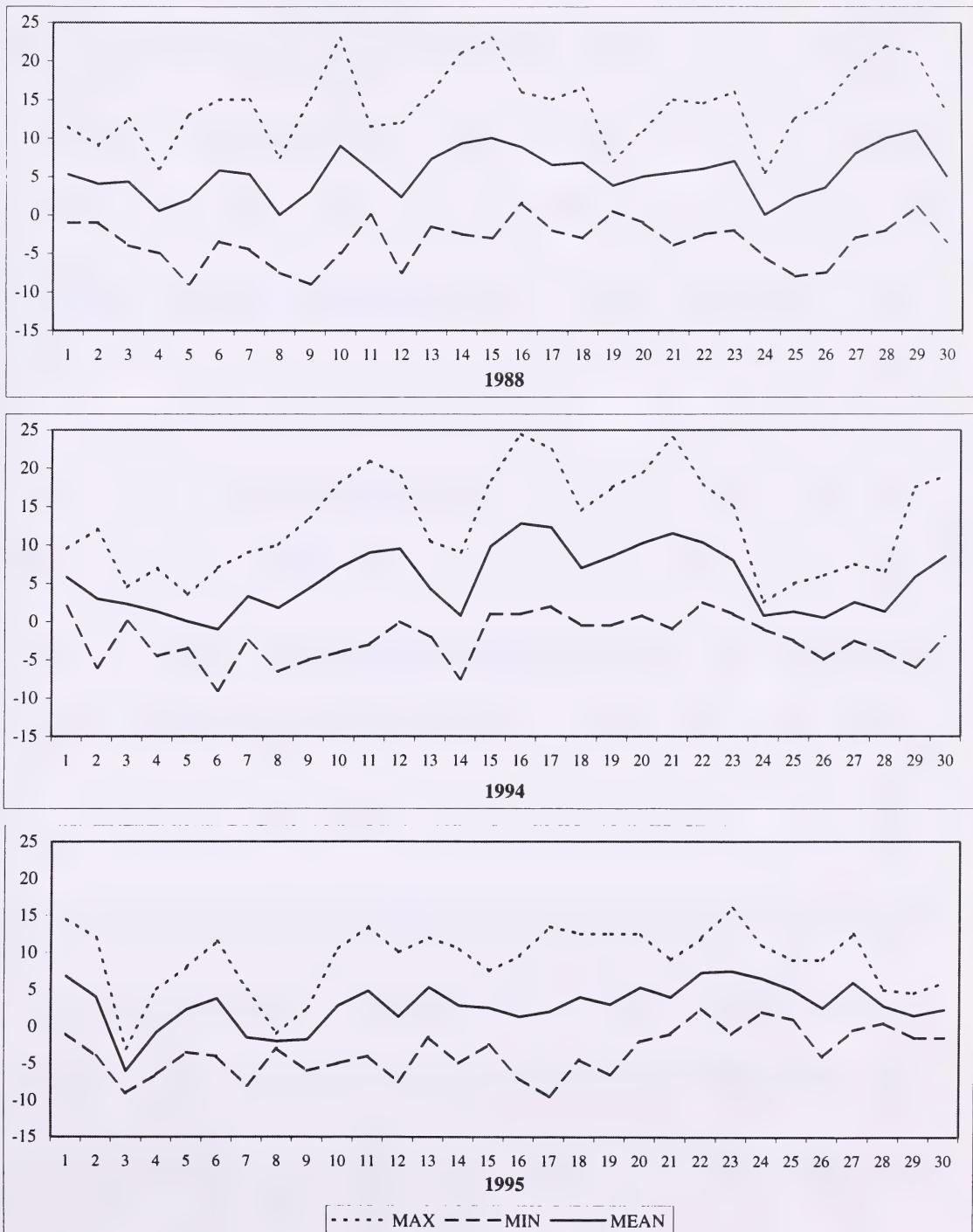
## March Weather Data for Sundre

DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>	DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>	DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>
3/1/88	1.5	-5.5	-2.0		3/1/94	14.7	-6.0	4.4		3/1/95	-1.5	-22.0	-11.8	
3/2/88	7.0	-10.5	-1.8		3/2/94	15.4	2.0	8.7		3/2/95	2.0	-14.0	-6.0	9.0
3/3/88	-1.0	-3.5	-2.3	7.0	3/3/94	10	-4.5	2.8	T	3/3/95	-12.5	-17.0	-14.8	3.0
3/4/88	2.5	-12.0	-4.8		3/4/94	11	-5.5	2.8	0.4	3/4/95	-19.0	-23.0	-21.0	1.2
3/5/88	8.0	-7.0	0.5		3/5/94	1	-5.0	-2.0	T	3/5/95	-17.5	-28.0	-22.8	T
3/6/88	7.0	-6.5	0.3		3/6/94	0.5	-7.0	-3.3		3/6/95	-11.5	-30.5	-21.0	
3/7/88	10.0	-6.0	2.0		3/7/94	0	-15.5	-7.8		3/7/95	-12.5	-30.5	-21.5	
3/8/88	16.0	-4.0	6.0		3/8/94	6.5	-13.0	-3.3		3/8/95	-10.5	-19.5	-15.0	
3/9/88	5.0	0.5	2.8		3/9/94	12.5	-9.0	1.8		3/9/95	7.0	-20.5	-6.8	
3/10/88	5.0	-4.5	0.3		3/10/94	4.5	-5.0	-0.3		3/10/95	14.5	-10.5	2.0	
3/11/88	4.0	-7.5	-1.8		3/11/94	10	-4.5	2.8		3/11/95	14.0	-3.0	5.5	
3/12/88	6.5	-10.5	-2.0		3/12/94	15	-3.5	5.8	T	3/12/95	14.0	-2.5	5.8	
3/13/88	10.0	-0.5	4.8	10.0	3/13/94	14	1.0	7.5		3/13/95	7.0	1.0	4.0	
3/14/88	0.0	-1.0	-0.5	16.0	3/14/94	9	-4.5	2.3		3/14/95	12.0	-3.5	4.3	
3/15/88	-0.5	-3.5	-2.0		3/15/94	10	-3.5	3.3		3/15/95	8.0	-1.0	3.5	
3/16/88	1.0	-18.0	-8.5		3/16/94	11	-3.5	3.8		3/16/95	9.0	0.5	4.8	
3/17/88	6.5	-12.0	-2.8		3/17/94	8.5	-5.0	1.8		3/17/95	10.0	-4.5	2.8	
3/18/88	12.0	-6.0	3.0		3/18/94	10	-5.5	2.3		3/18/95	10.0	-4.0	3.0	
3/19/88	12.5	-1.5	5.5		3/19/94	4	-3.5	0.3		3/19/95	12.5	-0.5	6.0	T
3/20/88	13.5	-5.5	4.0		3/20/94	6.5	-8.5	-1.0	13.0	3/20/95	10.0	-4.5	2.8	
3/21/88	8.5	-2.0	3.3		3/21/94	1.5	-6.5	-2.5	2.0	3/21/95	12.0	-2.0	5.0	
3/22/88	9.0	-5.5	1.8		3/22/94	-4	-7.5	-5.8		3/22/95	6.5	-5.0	0.8	
3/23/88	9.0	-2.5	3.3		3/23/94	-2	-16.7	-9.4		3/23/95	2.0	-4.5	-1.3	
3/24/88	8.0	-2.0	3.0		3/24/94	0.5	-14.0	-6.8		3/24/95	6.5	-5.5	0.5	
3/25/88	9.0	-2.0	3.5		3/25/94	7.5	-6.5	0.5		3/25/95	3.0	-6.0	-1.5	
3/26/88	10.0	-4.5	2.8	30.0	3/26/94	7.5	-0.5	3.5		3/26/95	4.0	-12.5	-4.3	
3/27/88	-2.0	-6.0	-4.0	10.0	3/27/94	15.5	-5.0	5.3		3/27/95	7.5	-9.5	-1.0	
3/28/88	0.5	-6.0	-2.8		3/28/94	9	-4.5	2.3		3/28/95	8.0	-8.5	-0.3	
3/29/88	2.0	-13.0	-5.5		3/29/94	17	-5.5	5.8		3/29/95	10.5	-6.0	2.3	
3/30/88	6.0	-9.0	-1.5		3/30/94	18	-4.0	7.0		3/30/95	16.0	-4.0	6.0	
3/31/88	15.5	-3.0	6.3		3/31/94	16.5	-2.0	7.3		3/31/95	18.0	-3.0	7.5	

<sup>a</sup>Degrees Celsius

<sup>b</sup>Snow in centimeters, rain in millimeters. Check temperatures to determine type of precipitation

### Sundre Weather for April



Temperatures on the Y axis are in degrees Celsius

## April Weather Data for Sundre

DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>	DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>	DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>
4/1/88	11.5	-1.0	5.3		4/1/94	9.5	2.0	5.8		4/1/95	14.5	-1.0	6.8	T
4/2/88	9.0	-1.0	4.0		4/2/94	12.0	-6.0	3.0	0.6	4/2/95	12.0	-4.0	4.0	8.0
4/3/88	12.5	-4.0	4.3		4/3/94	4.5	0.0	2.3		4/3/95	-3.0	-9.0	-6.0	2.0
4/4/88	6.0	-5.0	0.5		4/4/94	7.0	-4.5	1.3		4/4/95	5.0	-6.5	-0.8	T
4/5/88	13.0	-9.0	2.0		4/5/94	3.5	-3.5	0.0		4/5/95	8.0	-3.5	2.3	
4/6/88	15.0	-3.5	5.8		4/6/94	7.0	-9.0	-1.0		4/6/95	11.5	-4.0	3.8	
4/7/88	15.0	-4.5	5.3		4/7/94	9.0	-2.5	3.3		4/7/95	5.0	-8.0	-1.5	1
4/8/88	7.5	-7.5	0.0		4/8/94	10.0	-6.5	1.8		4/8/95	-1.0	-3.0	-2.0	2.0
4/9/88	15.0	-9.0	3.0		4/9/94	13.5	-5.0	4.3		4/9/95	2.5	-6.0	-1.8	T
4/10/88	23.0	-5.0	9.0		4/10/94	18.0	-4.0	7.0		4/10/95	10.5	-5.0	2.8	
4/11/88	11.5	0.0	5.8		4/11/94	21.0	-3.0	9.0		4/11/95	13.5	-4.0	4.8	
4/12/88	12.0	-7.5	2.3		4/12/94	19.0	0.0	9.5		4/12/95	10.0	-7.5	1.3	T
4/13/88	16.0	-1.5	7.3		4/13/94	10.5	-2.0	4.3		4/13/95	12.0	-1.5	5.3	
4/14/88	21.0	-2.5	9.3		4/14/94	9.0	-7.5	0.8		4/14/95	10.5	-5.0	2.8	T
4/15/88	23.0	-3.0	10.0		4/15/94	18.5	1.0	9.8		4/15/95	7.5	-2.5	2.5	
4/16/88	16.0	1.5	8.8		4/16/94	24.5	1.0	12.8		4/16/95	9.5	-7.0	1.3	
4/17/88	15.0	-2.0	6.5		4/17/94	22.5	2.0	12.3		4/17/95	13.5	-9.5	2.0	
4/18/88	16.5	-3.0	6.8	13.0	4/18/94	14.5	-0.5	7.0		4/18/95	12.5	-4.5	4.0	
4/19/88	7.0	0.5	3.8	1.6	4/19/94	17.5	-0.5	8.5		4/19/95	12.5	-6.5	3.0	0.2
4/20/88	11.0	-1.0	5.0		4/20/94	19.5	0.8	10.2		4/20/95	12.5	-2.0	5.3	4.2
4/21/88	15.0	-4.0	5.5		4/21/94	24.0	-1.0	11.5	0.2	4/21/95	9.0	-1.0	4.0	2.0
4/22/88	14.5	-2.5	6.0		4/22/94	18.0	2.5	10.3	1.3	4/22/95	12.0	2.5	7.3	0.8
4/23/88	16.0	-2.0	7.0		4/23/94	15.0	1.0	8.0	1.0	4/23/95	16.0	-1.0	7.5	T
4/24/88	5.5	-5.5	0.0		4/24/94	2.5	-1.0	0.8	4.2	4/24/95	11.0	2.0	6.5	4.8
4/25/88	12.5	-8.0	2.3		4/25/94	5.0	-2.5	1.3	1.0	4/25/95	9.0	1.0	5.0	0.6
4/26/88	14.5	-7.5	3.5		4/26/94	6.0	-5.0	0.5		4/26/95	9.0	-4.0	2.5	
4/27/88	19.0	-3.0	8.0		4/27/94	7.5	-2.5	2.5		4/27/95	12.5	-0.5	6.0	0.4
4/28/88	22.0	-2.0	10.0		4/28/94	6.5	-4.0	1.3		4/28/95	5.0	0.5	2.8	4.6
4/29/88	21.0	1.0	11.0		4/29/94	17.5	-6.0	5.8		4/29/95	4.5	-1.5	1.5	
4/30/88	13.5	-3.5	5.0		4/30/94	19.0	-2.0	8.5		4/30/95	6.0	-1.5	2.3	1.8

<sup>a</sup>Degrees Celsius

<sup>b</sup>Snow in centimeters, rain in millimeters. Check temperatures to determine type of precipitation

## May Weather Data for Sundre

DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>	DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>	DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>
5/1/88	10.5	-5.5	2.5		5/1/94	13.0	-1.5	5.8		5/1/95	5.0	0.0	2.5	T
5/2/88	14.0	-7.5	3.3		5/2/94	15.0	-3.0	6.0		5/2/95	4.5	-5.0	-0.3	
5/3/88	12.0	-8.0	2.0		5/3/94	14.5	0.5	7.5		5/3/95	10.5	-2.0	4.3	1.6
5/4/88	11.5	-1.0	5.3	0.2	5/4/94	14.0	-1.5	6.3		5/4/95	9.0	2.0	5.5	2.4
5/5/88	8.0	1.5	4.8	0.2	5/5/94	13.5	5.0	9.3		5/5/95	13.5	-1.5	6.0	0.4
5/6/88	14.0	-3.0	5.5		5/6/94	24.0	1.5	12.8		5/6/95	7.0	4.5	5.8	16.4
5/7/88	17.0	2.0	9.5		5/7/94	19.5	5.0	12.3		5/7/95	12.0	4.0	8.0	0.4
5/8/88	21.5	0.0	10.8		5/8/94	21.5	-3.0	9.3		5/8/95	16.0	-1.5	7.3	
5/9/88	23.5	6.0	14.8		5/9/94	28.0	0.5	14.3	T	5/9/95	18.5	-1.0	8.8	
5/10/88	24.0	3.0	13.5		5/10/94	18.0	8.5	13.3	0.2	5/10/95	23.0	0.0	11.5	
5/11/88	24.5	1.0	12.8		5/11/94	26.0	2.5	14.3		5/11/95	21.5	4.0	12.8	7.3
5/12/88	21.5	6.0	13.8		5/12/94	18.5	9.5	14.0	0.6	5/12/95	13.0	0.0	6.5	0.2
5/13/88	28.0	10.0	19.0		5/13/94	17.0	6.0	11.5	1.8	5/13/95	19.5	-1.5	9.0	
5/14/88	19.0	1.0	10.0		5/14/94	17.0	-0.7	8.2	0.2	5/14/95	23.0	2.5	12.8	1.6
5/15/88	21.5	-3.0	9.3		5/15/94	13.0	7.0	10.0	24.2	5/15/95	11.0	2.0	6.5	
5/16/88	28.0	4.5	16.3		5/16/94	17.0	5.0	11.0	T	5/16/95	20.0	-1.0	9.5	T
5/17/88	17.5	4.0	10.8		5/17/94	12.5	4.5	8.5		5/17/95	19.0	3.5	11.3	4.0
5/18/88	11.0	-1.0	5.0		5/18/94	10.0	4.5	7.3		5/18/95	12.0	4.0	8.0	
5/19/88	19.0	0.0	9.5		5/19/94	9.0	3.5	6.3	16.7	5/19/95	13.5	-0.5	6.5	
5/20/88	16.0	1.0	8.5		5/20/94	5.0	3.5	4.3	8.8	5/20/95	13.5	-0.5	6.5	
5/21/88	24.0	1.0	12.5		5/21/94	8.5	2.5	5.5	3.0	5/21/95	11.5	0.0	5.8	1.6
5/22/88	29.5	3.5	16.5		5/22/94	16.0	4.5	10.3	0.4	5/22/95	18.0	-1.0	8.5	
5/23/88	25.0	3.5	14.3		5/23/94	21.0	2.5	11.8		5/23/95	18.5	-1.0	8.8	
5/24/88	19.0	-0.5	9.3		5/24/94	22.5	4.5	13.5		5/24/95	14.0	0.0	7.0	
5/25/88	24.0	0.0	12.0		5/25/94	26.0	5.0	15.5		5/25/95	10.0	1.0	5.5	
5/26/88	22.5	3.5	13.0		5/26/94	23.0	7.5	15.3	2.4	5/26/95	17.0	-4.5	6.3	
5/27/88	22.5	4.5	13.5		5/27/94	13.0	6.0	9.5	3.4	5/27/95	24.0	-1.0	11.5	
5/28/88	24.0	2.5	13.3		5/28/94	17.5	1.0	9.3		5/28/95	27.0	6.5	16.8	
5/29/88	12.0	4.5	8.3	11.4	5/29/94	17.0	1.5	9.3	0.2	5/29/95	29.5	6.5	18.0	
5/30/88	13.5	7.5	10.5	7.6	5/30/94	16.5	0.0	8.3	0.4	5/30/95	29.5	6.5	18.0	
5/31/88	18.0	6.5	12.3		5/31/94	21.0	-1.0	10.0	T	5/31/95	21.5	5.5	13.5	

<sup>a</sup>Degrees Celsius

<sup>b</sup>Snow in centimeters, rain in millimeters. Check temperatures to determine type of precipitation.

DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>	DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>	DATE	MAX <sup>a</sup>	MIN <sup>a</sup>	MEAN <sup>a</sup>	PRECIP <sup>b</sup>
6/1/88	19.5	3.5	11.5		6/1/94	14.0	11.5	12.8	6.4	6/1/95	23.0	4.0	13.5	0.6
6/2/88	20.5	1.0	10.8		6/2/94	19.0	8.5	13.8		6/2/95	26.5	4.5	15.5	5.4
6/3/88	24.5	3.0	13.8		6/3/94	23.0	3.0	13.0		6/3/95	18.0	9.5	13.8	T
6/4/88	24.0	4.0	14.0	13.6	6/4/94	20.5	5.5	13.0	17.6	6/4/95	25.0	5.5	15.3	5.2
6/5/88	16.0	8.0	12.0	7.4	6/5/94	18.5	9.0	13.8	0.2	6/5/95	22.5	11.0	16.8	43.6
6/6/88	16.0	11.0	13.5	0.6	6/6/94	17.5	5.0	11.3	18.2	6/6/95	16.0	6.0	11.0	17.8
6/7/88	17.0	11.0	14.0	9.6	6/7/94	14.5	7.5	11.0	10.1	6/7/95	14.0	2.0	8.0	0.2
6/8/88	18.0	6.5	12.3	24.4	6/8/94	15.5	6.5	11.0	0.6	6/8/95	16.0	0.0	8.0	
6/9/88	21.5	5.5	13.5	0.7	6/9/94	20.0	6.5	13.3	T	6/9/95	19.5	1.0	10.3	
6/10/88	21.5	8.5	15.0	0.2	6/10/94	20.5	3.0	11.8		6/10/95	22.0	1.5	11.8	
6/11/88	15.0	3.5	9.3		6/11/94	22.0	5.5	13.8		6/11/95	20.0	8.5	14.3	0.4
6/12/88	17.0	4.5	10.8	3.6	6/12/94	22.0	7.5	14.8		6/12/95	25.0	7.0	16.0	
6/13/88	18.0	3.0	10.5	0.6	6/13/94	20.0	9.5	14.8	2.6	6/13/95	22.0	5.0	13.5	T
6/14/88	19.0	2.5	10.8	0.2	6/14/94	8.5	4.0	6.3	7.8	6/14/95	18.0	9.5	13.8	
6/15/88	25.5	3.5	14.5		6/15/94	8.5	1.5	5.0	1.6	6/15/95	25.0	7.0	16.0	
6/16/88	29.0	8.0	18.5		6/16/94	14.0	0.5	7.3		6/16/95	26.0	9.0	17.5	
6/17/88	28.0	14.5	21.3		6/17/94	18.0	3.5	10.8		6/17/95	21.0	11.0	16.0	
6/18/88	25.5	9.5	17.5		6/18/94	21.5	3.5	12.5		6/18/95	18.0	12.0	15.0	18.4
6/19/88	26.5	4.5	15.5		6/19/94	21.0	5.5	13.3	1.8	6/19/95	18.5	9.0	13.8	5.4
6/20/88	22.0	7.0	14.5		6/20/94	23.0	2.5	12.8		6/20/95	14.0	9.5	11.8	7.4
6/21/88	21.0	6.5	13.8		6/21/94	25.0	4.5	14.8		6/21/95	15.5	8.5	12.0	0.2
6/22/88	26.0	12.5	19.3	0.2	6/22/94	27.0	5.5	16.3		6/22/95	18.5	8.0	13.3	
6/23/88	26.5	8.5	17.5	0.4	6/23/94	26.5	7.5	17.0	2.2	6/23/95	22.5	6.5	14.5	
6/24/88	21.5	10.0	15.8		6/24/94	24.5	11.0	17.8	8.6	6/24/95	25.5	8.5	17.0	2.0
6/25/88	27.5	5.0	16.3	0.2	6/25/94	23.0	6.0	14.5	6.8	6/25/95	23.0	10.0	16.5	T
6/26/88	26.0	16.0	21.0	1.2	6/26/94	22.0	9.0	15.5	2.4	6/26/95	14.0	7.0	10.5	0.6
6/27/88	24.5	10.5	17.5	3.6	6/27/94	23.5	11.0	17.3		6/27/95	18.5	5.5	12.0	1.2
6/28/88	19.5	10.0	14.8	2.4	6/28/94	20.5	5.5	13.0		6/28/95	16.5	5.5	11.0	T
6/29/88	18.5	9.5	14.0	13.8	6/29/94	17.0	10.0	13.5	8.4	6/29/95	21.0	3.5	12.3	
6/30/88	22.5	8.0	15.3		6/30/94	21.0	4.5	12.8	2.8	6/30/95	23.5	6.0	14.8	

<sup>a</sup>Degrees Celsius  
<sup>b</sup>Snow in centimeters, rain in millimeters. Check temperature to determine type of precipitation

## **APPENDIX D**

### **CLINICOPATHOLOGY VALUES ORGANIZED FOR RANCHES A AND B**



ID NO.	Animal No.	Date Sampled	Matrix	Element	Concentration	Comment
940134	CALF Green #D-14	94.02.14	Liver	Cu Se	947 µg/g 5699 ng/g	Toxic High
			Kidney	Cu Se	12 µg/g 3099 ng/g	Toxic Adequate
940153	CALF	94.02.27	Liver	Cu Se	344 µg/g 2093 ng/g	Adequate Adequate
			Kidney	Cu Se	21 µg/g 4199 ng/g	High Adequate
940154	CALF Green #D-59	94.02.27	Liver	Cu Se	570 µg/g 6993 ng/g	High/ade High
			Kidney	Cu Se	14 µg/g 6309 ng/g	Adequate Adequate
940155	CALF Green #D-37	94.02.27	Liver	Cu Se	709 µg/g 2741 ng/g	High Adequate
			Kidney	Cu Se	28 µg/g 2676 ng/g	High Adequate
940159	CALF Yellow #102	94.03.08	Liver	Cu Se	541 µg/g 2162 ng/g	Adequate Adequate
			Kidney	Cu Se	11 µg/g 1780 ng/g	Marginal Ade/marg
900566	COW Green #8	94.03.17	Liver	Cu Se	94 µg/g 652 ng/g	Marginal Marg/def
			Kidney	Cu Se	16 µg/g 3667 ng/g	Marginal Ade/marg
940236	CALF Green #D-57	94.03.18	Liver	Cu Se	153 µg/g 1429 ng/g	Adequate Marg/def
			Kidney	Cu Se	32 µg/g 4555 ng/g	Adequate Adequate
940158	CALF Yellow #52	94.03.08	Liver	Cu Se	125 µg/g 874 ng/g	Adequate Deficient
			Kidney	Cu Se	14 µg/g 2907 ng/g	Adequate Ade/marg

ID No.	Animal No.	Date Sampled	Matrix	Element	Concentration	Comment
940132	COW White #134	94.02.11	Serum	Cu	422 ng/ml	Deficient
				Zn	994 ng/ml	Normal
				Se	73 ng/ml	Normal
940129	CALF #130	94.02.11	Serum	Cu	153 ng/ml	Deficient
				Zn	264 ng/ml	Deficient
				Se	512 ng/ml	Adequate
940128	COW White #123	94.02.11	Serum	Whole Blood	Cu	362 ng/ml
				Zn	1334 ng/ml	Adequate
				Se	411 ng/ml	Adequate
940127	COW #19	94.02.11	Plasma	Cu	627 ng/ml	Deficient
				Zn	894 ng/ml	Adequate
				Se	61 ng/ml	Marginal
940130	COW #154	94.02.11	Serum	Cu	707 ng/ml	Low-ade
				Zn	915 ng/ml	Adequate
				Se	53 ng/ml	Marginal
940131	COW #180	94.02.11	Serum	Cu	593 ng/ml	Deficient
				Zn	871 ng/ml	Adequate
				Se	62 ng/ml	Marginal
940119	CALF #19	94.02.22	Liver	Cu	280 µg/g	Adequate
			Kidney	Se	4954 ng/g	High
				Cu	24 µg/g	Ade/high
940135		94.02.16	Liver	Se	2875 ng/g	Ade/marg
			Kidney	Cu	293 µg/g	Adequate
				Se	2877 ng/g	Ade/high
940136	CALF #98	94.02.16	Liver	Cu	14 µg/g	Adequate
			Kidney	Se	1866 ng/g	Ade/marg
				Cu	524 µg/g	Adequate
940137	CALF White #46	94.02.22	Liver	Se	8646 ng/g	High
			Kidney	Cu	18 µg/g	Adequate
				Se	3669 ng/g	Adequate
940237	CALF White #2	94.03.18	Liver	Cu	501 µg/g	Adequate
			Kidney	Se	16 µg/g	High/toxic
				Cu	19 µg/g	Adequate
940238	CALF Blue #8	94.03.18	Liver	Se	2907 ng/g	Adequate
			Kidney	Cu	121 µg/g	High
				Se	3769 ng/g	Marg/ade
			Liver	Cu	16 µg/g	Marginal
			Kidney	Se	2548 ng/g	Marg/def
				Cu	107 µg/g	Low ade
			Liver	Se	1544 ng/g	Marg/def
			Kidney	Cu	25 µg/g	Adequate
				Se	3251 ng/g	Ade/marg

ID NO.	Animal No.	Matrix	Mineral	Concentration <sup>a</sup>	Comment
911075	Gr 66	Plasma	Se	50 ng/ml	Low Marginal
			Cu	850 ng/ml	Adequate
			Zn	1330 ng/ml	Adequate
930607	Gr 18	Plasma	Se	52 ng/ml	Low Marginal
			Cu	601 ng/ml	Deficient
			Zn	1190 ng/ml	Adequate
940050	Gr 106	WBlood	Se	130 ng/ml	Marginal
			Se	67 ng/ml	Marginal
			Cu	801 ng/ml	Adequate
	WBlood	Se	Zn	1080 ng/ml	Adequate
			Se	173 ng/ml	Low Adequate
			Se	40 ng/ml	Deficient
940295	Y 103	Plasma	Cu	576 ng/ml	Deficient
			Zn	1080 ng/ml	Adequate
	WBlood	Se	Se	97 ng/ml	Low Marginal
			Cu	36 ng/ml	Deficient
			Zn	1100 ng/ml	Adequate
940327	Y 154	Plasma	Zn	1730 ng/ml	Adeqaute
			Se	36 ng/ml	Deficient
			Cu	992 ng/ml	Adequate
	WBlood	Se	Zn	1570 ng/ml	Adequate
			Se	34 ng/ml	Deficient
			Cu	847 ng/ml	Adequate
940328	Gr D119	Plasma	Zn	1890 ng/ml	Adequate
			Se	153 ng/ml	Marginal
			Cu	41 ng/ml	Deficient
	Y 158	Plasma	Zn	1310 ng/ml	Adequate
			Se	1560 ng/ml	Adequate
			Cu	46 ng/ml	Deficient
940329	Y 158	WBlood	Zn	859 ng/ml	Adequate
			Se	1730 ng/ml	Adequate
			Cu	33 ng/ml	Deficient
	Y 155	Plasma	Zn	664 ng/ml	Deficient
			Se	1080 ng/ml	Adequate
			Cu	46 ng/ml	Deficient
940330	Y 160	Plasma	Zn	859 ng/ml	Adequate
			Se	1730 ng/ml	Adequate
			Cu	31 ng/ml	Deficient
	Y 156	Plasma	Zn	664 ng/ml	Deficient
			Se	1080 ng/ml	Adequate
			Cu	46 ng/ml	Deficient
940333	Gr D121	Plasma	Zn	854 ng/ml	Adequate
			Se	1300 ng/ml	Adequate
			Cu	31 ng/ml	Deficient

ID NO.	Animal No.	Matrix	Mineral	Concentration <sup>a</sup>	Comment
940334	Gr D118	Plasma	Se Cu Zn	34 ng/ml 976 ng/ml 1300 ng/ml	Deficient Adequate Adequate
940335	Gr D122	Plasma	Se Cu Zn	31 ng/ml 433 ng/ml 1990 ng/ml	Deficient Deficient Adequate
940336	Gr D120	Plasma	Se Cu Zn	37 ng/ml 714 ng/ml 1110 ng/ml	Deficient Low Adequate Adequate
940337	Y 161	Plasma	Se Cu Zn	38 ng/ml 544 ng/ml 2520 ng/ml	Deficient Deficient High
940338	Gr D123	Plasma	Se Cu Zn	50 ng/ml 614 ng/ml 1830 ng/ml	Low Marginal Deficient Adequate
940339	Gr 122	Plasma	Se Cu Zn	61 ng/ml 847 ng/ml 1110 ng/ml	Marginal Adequate Adequate
		WBlood	Se	140 ng/ml	Marginal
940340	Gr 101	Plasma	Se Cu Zn	64 ng/ml 702 ng/ml 1150 ng/ml	Marginal Low Adequate Adequate
		WBlood	Se	187 ng/ml	Low Adequate
940341	Bk 6	Plasma	Se Cu Zn	74 ng/ml 814 ng/ml 295 ng/ml	Adequate Adequate Deficient
		WBlood	Se	167 ng/ml	Low Adequate
940342	Gr 211	Plasma	Se Cu Zn	106 ng/ml 1160 ng/ml 790 ng/ml	Adequate Adequate Adequate
		WBlood	Se	194 ng/ml	Low Adequate
940343	Gr 45	Plasma	Se Cu Zn	72 ng/ml 758 ng/ml 1200 ng/ml	Adequate Low Adequate Adequate
		WBlood	Se	160 ng/ml	Marginal

ID NO.	Animal No.	Matrix	Mineral	Concentration <sup>a</sup>	Comment
940344	Gr 49	Plasma	Se	69 ng/ml	Marginal
			Cu	1050 ng/ml	Adequate
			Zn	885 ng/ml	Adequate
940345	Gr 162	WBlood	Se	173 ng/ml	Low Adequate
			Se	57 ng/ml	Marginal
			Cu	1010 ng/ml	Adequate
940346	Gr 36	WBlood	Zn	959 ng/ml	Adequate
			Se	170 ng/ml	Low Adequate
			Cu	88 ng/ml	Adequate
940242	Gr D66	Plasma	Cu	554 ng/ml	Deficient
			Cu	1150 ng/ml	Adequate
			Se	157 ng/ml	Marginal
940244	Gr 145	Liver	Cu	573 µg/g	Adequate
			Se	800 ng/g	Marginal
			Fe	363 µg/g	Adequate
940245	Gr 208 calf	Kidney	Cu	38 µg/g	High
			Se	4320 ng/g	Adequate
			Cu	876 ng/ml	Adequate
940247	Steer	Serum	Se	71 ng/ml	Marginal
			Cu	214 µg/g	Adequate
			Se	1100 ng/g	Adequate
940245	Gr 208 calf	Liver	Fe	599 µg/g	Adequate
			Cu	14 µg/g	Low Adequate
			Se	7030 ng/g	High
940245	Gr 208 calf	Kidney	Cu	686 µg/g	High
			Se	1540 ng/g	Adequate
			Fe	552 µg/g	Adequate
940247	Steer	Liver	Cu	33 µg/g	High
			Se	4200 ng/g	Adequate
			Cu	397 µg/g	Adequate
940247	Steer	Kidney	Se	699 ng/g	Marginal
			Fe	328 µg/g	Adequate
			Cu	15 µg/g	Low Adequate
940247	Steer	Kidney	Se	5730 ng/g	Adequate

ID NO.	Animal No.	Matrix	Mineral	Concentration <sup>a</sup>	Comment		
940251	Gr D29	Liver	Cu	89 µg/g	Marginal		
			Se	359 ng/g	Deficient		
			Fe	97 µg/g	Deficient		
	Y 49	Kidney	Cu	14 µg/g	Low Adequate		
			Se	3420 ng/g	Marginal		
			Cu	107 µg/g	Low Adequate		
940288	Y 49	Liver	Se	678 ng/g	Marginal		
940293	Gr 63	Plasma	Cu	13 µg/g	Low Adequate		
			Se	3620 ng/g	Marginal		
			Zn	77 ng/ml	Adequate		
940294	Bk 38	Plasma	Cu	1320 ng/ml	Adequate		
940295 (94.04.14)			Zn	419 ng/ml	Deficient		
			Se	64 ng/ml	Marginal		
			Cu	1360 ng/ml	Adequate		
			Zn	430 ng/ml	Deficient		
940295 (94.04.14)	Y 103	Plasma	Se	68 ng/ml	Marginal		
			Cu	545 ng/ml	Deficient		
			Zn	643 ng/ml	Deficient		

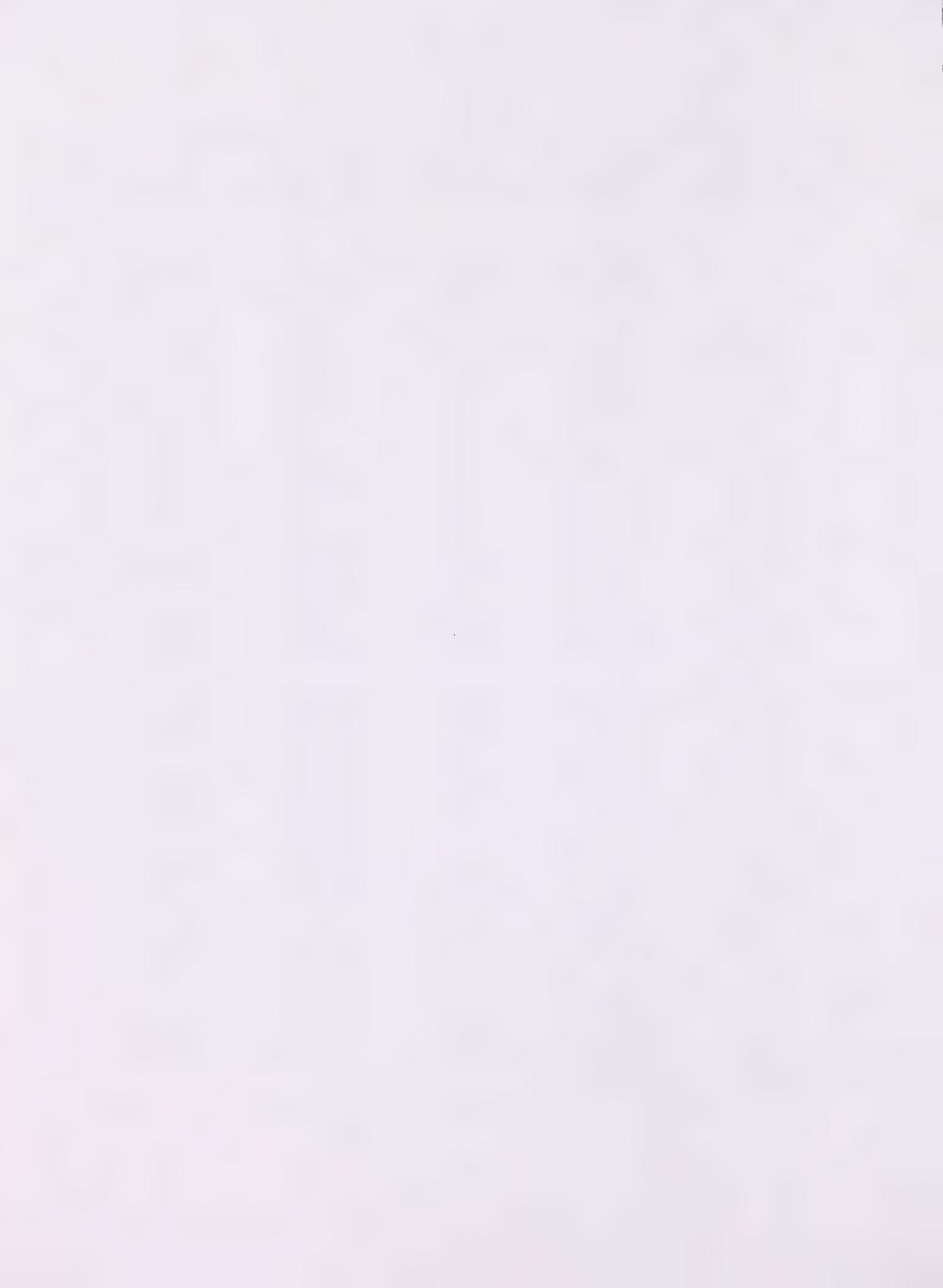
<sup>a</sup> Organ tissue concentrations are on a dry weight basis

ID No.	Animal No.	Matrix	Mineral	Concentration <sup>a</sup>	Comment
940249	2B calf	Liver	Cu	179 µg/g	Adequate
			Se	2470 ng/g	Adequate
			Fe	171 µg/g	Low Ade
	195 calf	Kidney	Cu	13 µg/g	Marginal
			Se	4130 ng/g	Low Ade
940250	195 calf	Liver	Cu	64 µg/g	Marginal
			Se	1400 ng/g	Adequate
			Fe	105 µg/g	Deficient
		Kidney	Cu	13 µg/g	Marginal
			Se	2650 ng/g	Marginal
940278	22 B	Liver	Cd	217 ng/g	Normal
			Cu	226 µg/g	Adequate
			Se	925 ng/g	Marginal
	Kidney	Kidney	Se	4290 ng/g	Adequate
			Cd	1530 ng/g	Normal
			Cu	54 µg/g	High-toxic
	Plasma	Plasma	Cu	633 ng/ml	Deficient
			Se	68 ng/ml	Marginal
			Zn	2040 ng/ml	High Ade
	WBlood	WBlood	Se	143 ng/ml	Marginal-Adequate
940287	170 calf	Liver	Se	1880 ng/g	Adequate
			Cu	350 µg/g	Adequate
	Kidney	Kidney	Se	4370 ng/g	Adequate
			Cu	15 µg/g	Marginal-Adequate
940299	84 White	Plasma	Se	119 ng/ml	Adequate
			Cu	1460 ng/ml	Adequate
			Zn	608 ng/ml	Deficient
	WBlood	WBlood	Se	230 ng/ml	Adequate
	Liver	Liver	Cu	87 µg/g	Marginal
			Se	1190 ng/g	Low Ade
	Kidney	Kidney	Cu	18 µg/g	Adequate
			Se	5080 ng/g	Adequate

ID No.	Animal No.	Matrix	Mineral	Concentration <sup>a</sup>	Comment
940301		WBlood	Se	228 ng/ml	
		Plasma	Se	177 ng/ml	
			Cu	1070 ng/ml	
			Zn	841 ng/ml	
940311	BT 170	WBlood	Se	191 ng/ml	Adequate
		Plasma	Se	74 ng/ml	Adequate
			Zn	1390 ng/ml	Adequate
			Cu	1160 ng/ml	Adequate
940312	BT 61	WBlood	Se	203 ng/ml	Adequate
		Plasma	Se	80 ng/ml	Adequate
			Zn	844 ng/ml	Adequate
			Cu	1140 ng/ml	Adequate
940313	BT 15	WBlood	Se	177 ng/ml	Adequate
		Plasma	Se	74 ng/ml	Adequate
			Zn	1350 ng/ml	Adequate
			Cu	1160 ng/ml	Adequate
940314	BT 89	WBlood	Se	124 ng/ml	Marginal
		Plasma	Se	49 ng/ml	Deficient
			Zn	1090 ng/ml	Adequate
			Cu	1120 ng/ml	Adequate
940315	BT 64	WBlood	Se	204 ng/ml	Adequate
		Plasma	Se	97 ng/ml	Adequate
			Zn	806 ng/ml	Adequate
			Cu	1030 ng/ml	Adequate
940316	BT 153	WBlood	Se	235 ng/ml	Adequate
		Plasma	Se	83 ng/ml	Adequate
			Zn	756 ng/ml	Low Ade
			Cu	1410 ng/ml	Adequate

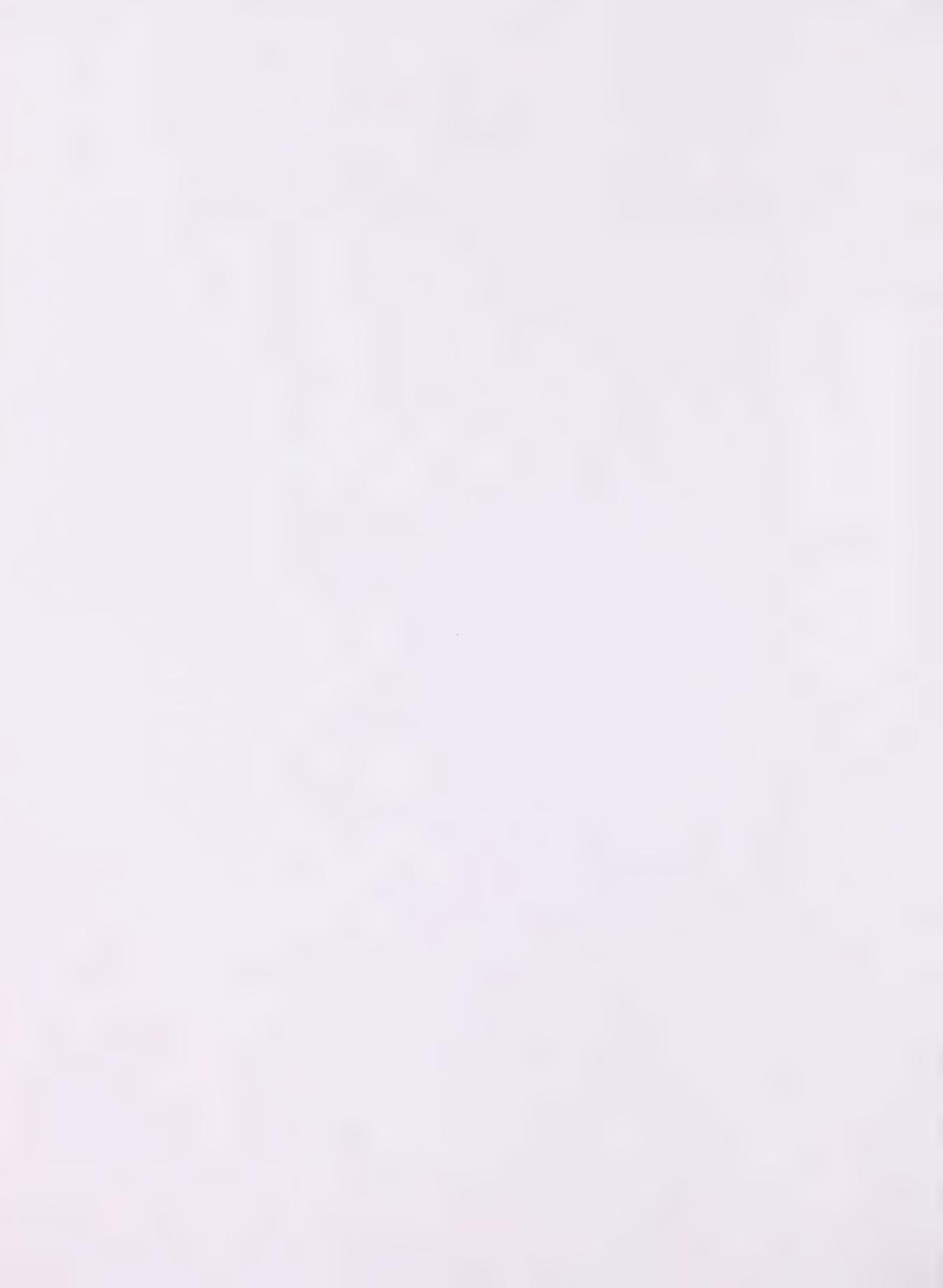
ID No.	Animal No.	Matrix	Mineral	Concentration <sup>a</sup>	Comment
940317	BT 17	WBlood	Se	202 ng/ml	Adequate
		Plasma	Se	82 ng/ml	Adequate
			Zn	842 ng/ml	Adequate
			Cu	786 ng/ml	Low Ade
940318	BT 50 Blue	WBlood	Se	207 ng/ml	Adequate
		Plasma	Se	82 ng/ml	Adequate
			Zn	878 ng/ml	Adequate
			Cu	1230 ng/ml	Adequate
940319	61 calf	Plasma	Se	43 ng/ml	Deficient
			Zn	760 ng/ml	Low Ade
			Cu	1370 ng/ml	Adequate
940320	15 calf	Plasma	Se	46 ng/ml	Deficient
			Zn	669 ng/ml	Deficient
			Cu	801 ng/ml	Adequate
940321	89 calf	Plasma	Se	46 ng/ml	Deficient
			Zn	1120 ng/ml	Adequate
			Cu	934 ng/ml	Adequate
940322	89-1 calf	Plasma	Se	53 ng/ml	Marginal
			Zn	1230 ng/ml	Adequate
			Cu	961 ng/ml	Adequate
940323	64 calf	Plasma	Se	41 ng/ml	Deficient
			Zn	1130 ng/ml	Adequate
			Cu	983 ng/ml	Adequate
940324	153 calf	Plasma	Se	45 ng/ml	Deficient
			Zn	1150 ng/ml	Adequate
			Cu	784 ng/ml	Low Ade
940325	17 calf	Plasma	Se	45 ng/ml	Deficient
			Zn	1060 ng/ml	Adequate
			Cu	705 ng/ml	Low Ade
940326	50 calf	Plasma	Se	46 ng/ml	Deficient
			Zn	1890 ng/ml	Adequate
			Cu	1700 ng/ml	Adequate

<sup>a</sup>Organ tissue concentrations are on a dry weight basis



## **APPENDIX E**

### **CONCENTRATION OF TRACE NUTRIENTS IN ANIMAL TISSUES**



Bovine Hematology (Ranch A)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	#911075 Gr66	#940050 Gr106
<b>Red Blood Count</b>	$\times 10^{12}/L$	7.87	6.05 - 9.70	6.75	6.34
<b>Hemoglobin</b>	g/L	127	99 - 156	124	116
<b>Hematocrit</b>		0.36	0.27 - 0.44	0.36	0.32
<b>Mean corpuscular volume</b>	fL	45	34 - 56	53	51
<b>Mean corpuscular hemoglobin</b>	pg	16	13 - 19	18	18
<b>Mean corpuscular hemoglobin conc.</b>	g/L	356	329 - 382	348	361
<b>Red cell Distribution width</b>	%	23	5.4 - 41	9.1	8.7
<b>Platelets</b>	$\times 10^9/L$	425	189 - 662	451	388
<b>Mean Platelet volume</b>	fL	7.0	5.1 - 8.9	7.3	6.7
<b>White Blood Count</b>	$\times 10^9/L$	8.5	4.5 - 12.5	7.1	10.3
<b>Neutrophils Rel.</b>		0.21	0.05 - 0.37	0.37	0.37
<b>Abs.</b>	$\times 10^9/L$	1.76	0.22 - 4.59	2.6	3.8
<b>Bands Rel.</b>		0	0	-	-
<b>Abs.</b>	$\times 10^9/L$	0	0 - 0.05	-	-
<b>Lymphocytes Rel.</b>		0.70	0.48 - 0.93	0.48	0.42
<b>Abs.</b>	$\times 10^9/L$	6.0	2.2 - 11.61	3.4	4.3
<b>Monocytes Rel.</b>		0.04	0 - 0.08	-	0.01
<b>Abs.</b>	$\times 10^9/L$	0.30	0 - 1.03	-	0.1
<b>Eosinophils Rel.</b>		0.05	0 - 0.14	0.13	0.20
<b>Abs.</b>	$\times 10^9/L$	0.46	0 - 1.77	0.9	2.06
<b>Basophils Rel.</b>		0	0 - 0.01	0.01	-
<b>Abs.</b>	$\times 10^9/L$	0	0 - 0.08	0.07	-
<b>Fibrinogen</b>	g/L			2	3

## Bovine Clinical Chemistry (Ranch A)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 911075 Gr 66	# 940295 Y103
CPK	U/L	228	55 - 401	126	326
LDH	U/L	1267	939 - 1595	986	938
SGOT/AST	U/L	80	62 - 98	85	116
SGPT/ALT	U/L	37	0 - 40	25	21
Alk. Phos.	U/L	149	0 - 312	42	38
Gamma GT	U/L	16	9 - 23	13	27
Total Bilirubin	µmol/L	2	0 - 4	4	1
Glucose	mmol/L	4.8	3.1 - 6.4	5.3	3.2
BUN	mmol/L	8.1	6.6 - 9.6	2.6	5.5
Creatinine	µmol/L	165	138 - 192	224	137
Uric acid	µmol/L		24 - 37	40	29
Calcium	mmol/L	2.45	2.26-2.64	2.26	1.98
Phosphorus	mmol/L	2.00	1.50-2.50	1.02	2.55
Magnesium	mmol/L	0.94	0.81-1.08	0.75	0.92
Total Protein	G/L		72 - 82	74	78
Albumin	G/L		34 - 40	34	26
Alb/Glob ratio		0.92	0.80-1.05	0.85	0.50
Sodium	mmol/L	142	138 - 145	140	145
Potassium	mmol/L	4.1	3.5 - 4.7	5.4	4.3
Chloride	mmol/L	101	98 - 104	95	101
Iron	µmol/L	29	20 - 37	27	24
Iron BC	µmol/L	46	37 - 55	29	24
TIBC	µmol/L	75	57 - 92	56	48
Amylase	U/L	31		79	85

## Bovine Clinical Chemistry (Ranch A)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 930607 Gr 18	# 940050 Gr 106
CPK	U/L	228	55 - 401	112	116
LDH	U/L	1267	939 - 1595	874	1050
SGOT/AST	U/L	80	62 - 98	89	79
SGPT/ALT	U/L	37	0 - 40	27	26
Alk. Phos.	U/L	149	0 - 312	27	38
Gamma GT	U/L	16	9 - 23	13	19
Total Bilirubin	µmol/L	2	0 - 4	6	2
Glucose	mmol/L	4.8	3.1 - 6.4	4.4	4.3
BUN	mmol/L	8.1	6.6 - 9.6	2.6	3.6
Creatinine	µmol/L	165	138 - 192	186	146
Uric acid	µmol/L		24 - 37	63	39
Calcium	mmol/L	2.45	2.26-2.64	2.22	2.19
Phosphorus	mmol/L	2.00	1.50-2.50	0.86	0.84
Magnesium	mmol/L	0.94	0.81-1.08	0.59	0.68
Total Protein	G/L		72 - 82	71	67
Albumin	G/L		34 - 40	33	31
Alb/Glob ratio		0.92	0.80-1.05	0.87	0.86
Sodium	mmol/L	142	138 - 145	145	143
Potassium	mmol/L	4.1	3.5 - 4.7	4.1	3.6
Chloride	mmol/L	101	98 - 104	96	97
Iron	µmol/L	29	20 - 37	19	22
Iron BC	µmol/L	46	37 - 55	32	32
TIBC	µmol/L	75	57 - 92	51	54
Amylase	U/L	31		69	81

## Bovine Clinical Chemistry (Ranch A)

Test	S.I. Unit	AEC Normals - Adults		Animal ID
		Mean	Range	# 940244 Gr 145
CPK	U/L	228	55 - 401	913
LDH	U/L	1267	939 - 1595	1336
SGOT/AST	U/L	80	62 - 98	204
SGPT/ALT	U/L	37	0 - 40	23
Alk. Phos.	U/L	149	0 - 312	39
Gamma GT	U/L	16	9 - 23	26
Total Bilirubin	µmol/L	2	0 - 4	1
Glucose	mmol/L	4.8	3.1 - 6.4	3.9
BUN	mmol/L	8.1	6.6 - 9.6	3.2
Creatinine	µmol/L	165	138 - 192	238
Uric acid	µmol/L		24 - 37	43
Calcium	mmol/L	2.45	2.26-2.64	1.98
Phosphorus	mmol/L	2.00	1.50-2.50	1.59
Magnesium	mmol/L	0.94	0.81-1.08	0.82
Total Protein	G/L		72 - 82	83
Albumin	G/L		34 - 40	30
Alb/Glob ratio		0.92	0.80-1.05	0.57
Sodium	mmol/L	142	138 - 145	147
Potassium	mmol/L	4.1	3.5 - 4.7	4.0
Chloride	mmol/L	101	98 - 104	111
Iron	µmol/L	29	20 - 37	18
Iron BC	µmol/L	46	37 - 55	30
TIBC	µmol/L	75	57 - 92	48
Amylase	U/L	31		76

## Bovine Clinical Chemistry (Ranch A)

TEST	S.I. UNIT	AEC Normals-Adults		Animal ID
		Mean	Range	# 940251 Calf D-29
Glucose	mmol/L	4.8	3.1 - 6.4	5.3
BUN	mmol/L	8.1	6.6 - 9.6	25.4
Creatinine	µmol/L	165	138 - 192	260
Total Protein	g/L	77	72 - 82	51
Albumin	g/L	37	34 - 40	28
Calcium	mmol/L	2.45	2.26-2.64	2.59
Phosphorus	mmol/L	2.00	1.50-2.50	2.95
Magnesium	mmol/L	0.94	0.81-1.08	0.89
Alb/Glob ratio	g/L	0.92	0.80-1.05	1.22
Sodium	mmol/L	142	138 - 145	169
Potassium	mmol/L	4.1	3.5 - 4.7	4.6
Chloride	mmol/L	101	98 - 104	124
Iron	µmol/L	29	20 - 37	3
Iron BC	µmol/L	46	37 - 55	75
TIBC	µmol/L	75	57 - 92	78
Total Bilirubin	µmol/L	2	0 - 4	11
Direct Bilirubin	µmol/L	0	0 - 1	5
Alk. Phos.	U/L	149	0 - 312	477
LDH	U/L	1267	939 - 1595	1585
CPK	U/L	228	55 - 401	655
SGOT/AST	U/L	80	62 - 98	272
SGPT/ALT	U/L	37	0 - 40	97
Gamma GT	U/L	16	9 - 23	217
Amylase	U/L	31	22 - 40	115

## Bovine Hematology (Ranch A)

Test	S.I. Unit	AEC Normals -Adults		Animal ID
		Mean	Range	#940251 Calf D-29
<b>Red Blood Count</b>	$\times 10^{12}/L$	7.87	6.05 - 9.70	2.63 <sup>a</sup>
Hemoglobin	g/L	127	99 - 156	47
<b>Hematocrit</b>		0.36	0.27 - 0.44	0.11
<b>Mean corpuscular volume</b>	fL	45	34 - 56	43 <sup>b</sup>
<b>Mean corpuscular hemoglobin</b>	Pg	16	13 - 19	18
<b>Mean corpuscular hemoglobin conc.</b>	g/L	356	329 - 382	420
<b>Red cell Distribution width</b>	%	23	5.4 - 41	18.6
<b>Platelets</b>	$\times 10^9/L$	425	189 - 662	- <sup>c</sup>
<b>Mean Platelet volume</b>	fL	7.0	5.1 - 8.9	- <sup>c</sup>
<b>White Blood Count</b>	$\times 10^9/L$	8.5	4.5 - 12.5	7.4
<b>Neutrophils Rel.</b>		0.21	0.05 - 0.37	0.56
<b>Abs.</b>	$\times 10^9/L$	1.76	0.22 - 4.59	4.1
<b>Bands Rel.</b>		0	0	0.01
<b>Abs.</b>	$\times 10^9/L$	0	0 - 0.05	0.07
<b>Lymphocytes Rel.</b>		0.70	0.48 - 0.93	0.41
<b>Abs.</b>	$\times 10^9/L$	6.0	2.2 - 11.61	3.03
<b>Monocytes Rel.</b>		0.04	0 - 0.08	0.02
<b>Abs.</b>	$\times 10^9/L$	0.30	0 - 1.03	0.15
<b>Eosinophils Rel.</b>		0.05	0 - 0.14	-
<b>Abs.</b>	$\times 10^9/L$	0.46	0 - 1.77	-
<b>Basophils Rel.</b>		0	0 - 0.01	-
<b>Abs.</b>	$\times 10^9/L$	0	0 - 0.08	-
<b>Fibrinogen</b>	g/L			11

<sup>a</sup> Marked anisocytosis. Many very small RBC's, moderately large RBC's. Basophilic stippling, Howell Jolly bodies, mild polychromasia, all tiny cells show marked crenation. Two nucleated RBCs per 100 WBC

<sup>b</sup> Not all cells may have been counted due to their small size

<sup>c</sup> Unable to perform

Bovine Clinical Chemistry (Ranch A)

Test	S.I. Unit	AEC Normals-Adults		Animal ID	
		Mean	Range	# 940293 <sup>a</sup> Calf Gr 63	# 940294 <sup>b</sup> Cow Bl 38
<b>Glucose</b>	mmol/L	4.8	3.1 - 6.4	5.3	3.1
<b>BUN</b>	mmol/L	8.1	6.6 - 9.6	4.5	17.8
<b>Creatinine</b>	µmol/L	165	138 - 192	105	184
<b>Total Protein</b>	g/L	77	72 - 82	53	67
<b>Albumin</b>	g/L	37	34 - 40	29	25
<b>Calcium</b>	mmol/L	2.45	2.26-2.64	1.99	1.98
<b>Phosphorus</b>	mmol/L	2.00	1.50-2.50	1.32	2.26
<b>Magnesium</b>	mmol/L	0.94	0.81-1.08	0.65	1.86
<b>Alb/Glob ratio</b>	g/L	0.92	0.80-1.05	1.21	0.60
<b>Sodium</b>	mmol/L	142	138 - 145	140	136
<b>Potassium</b>	mmol/L	4.1	3.5 - 4.7	3.8	3.2
<b>Chloride</b>	mmol/L	101	98 - 104	97	91
<b>Iron</b>	µmol/L	29	20 - 37	18	8
<b>Iron BC</b>	µmol/L	46	37 - 55	44	31
<b>TIBC</b>	µmol/L	75	57 - 92	62	39
<b>Total Bilirubin</b>	µmol/L	2	0 - 4	1	28
<b>Direct Bilirubin</b>	µmol/L	0	0 - 1		4
<b>Alk. Phos.</b>	U/L	149	0 - 312	134	96
<b>LDH</b>	U/L	1267	939 - 1595	3100	3190
<b>CPK</b>	U/L	228	55 - 401	3950	1890
<b>SGOT/AST</b>	U/L	80	62 - 98	720	263
<b>SGPT/ALT</b>	U/L	37	0 - 40	197	29
<b>Gamma GT</b>	U/L	16	9 - 23	8	33
<b>Amylase</b>	U/L	31	22 - 40	97	74

<sup>a</sup> Hemoglobin of 119 g/L

<sup>b</sup> Hemoglobin of 127 g/L

Bovine Hematology (Ranch A)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	#940293	#940294
<b>Red Blood Count</b>	$\times 10^{12}/L$	7.87	6.05 - 9.70		
<b>Hemoglobin</b>	g/L	127	99 - 156	119 <sup>a</sup>	127 <sup>a</sup>
<b>Hematocrit</b>		0.36	0.27 - 0.44		
<b>Mean corpuscular volume</b>	fL	45	34 - 56		
<b>Mean corpuscular hemoglobin</b>	Pg	16	13 - 19		
<b>Mean corpuscular hemoglobin conc.</b>	g/L	356	329 - 382		
<b>Red cell Distribution width</b>	%	23	5.4 - 41		
<b>Platelets</b>	$\times 10^9/L$	425	189 - 662		
<b>Mean Platelet volume</b>	fL	7.0	5.1 - 8.9		
<b>White Blood Count</b>	$\times 10^9/L$	8.5	4.5 - 12.5		
<b>Neutrophils Rel.</b>		0.21	0.05 - 0.37		
<b>Abs.</b>	$\times 10^9/L$	1.76	0.22 - 4.59		
<b>Bands Rel.</b>		0	0		
<b>Abs.</b>	$\times 10^9/L$	0	0 - 0.05		
<b>Lymphocytes Rel.</b>		0.70	0.48 - 0.93		
<b>Abs.</b>	$\times 10^9/L$	6.0	2.2 - 11.61		
<b>Monocytes Rel.</b>		0.04	0 - 0.08		
<b>Abs.</b>	$\times 10^9/L$	0.30	0 - 1.03		
<b>Eosinophils Rel.</b>		0.05	0 - 0.14		
<b>Abs.</b>	$\times 10^9/L$	0.46	0 - 1.77		
<b>Basophils Rel.</b>		0	0 - 0.01		
<b>Abs.</b>	$\times 10^9/L$	0	0 - 0.08		
<b>Fibrinogen</b>	g/L			8	9

<sup>a</sup> Unable to provide accurate results for other parameters due to age of samples

Bovine Clinical Chemistry (Ranch A)

Test	S.I. Unit	AEC Normals-Adults		# 940295 <sup>a</sup> Cow Yel
		Mean	Range	
Glucose	mmol/L	4.8	3.1 - 6.4	3.2
BUN	mmol/L	8.1	6.6 - 9.6	3.7
Creatinine	µmol/L	165	138 - 192	160
Total Protein	g/L	77	72 - 82	78
Albumin	g/L	37	34 - 40	28
Calcium	mmol/L	2.45	2.26-2.64	2.08
Phosphorus	mmol/L	2.00	1.50-2.50	1.73
Magnesium	mmol/L	0.94	0.81-1.08	0.76
Alb/Glob ratio	g/L	0.92	0.80-1.05	0.56
Sodium	mmol/L	142	138 - 145	136
Potassium	mmol/L	4.1	3.5 - 4.7	4.3
Chloride	mmol/L	101	98 - 104	94
Iron	µmol/L	29	20 - 37	19
Iron BC	µmol/L	46	37 - 55	24
TIBC	µmol/L	75	57 - 92	43
Total Bilirubin	µmol/L	2	0 - 4	3
Direct Bilirubin	µmol/L	0	0 - 1	
Alk. Phos.	U/L	149	0 - 312	32
LDH	U/L	1267	939 - 1595	745
CPK	U/L	228	55 - 401	112
SGOT/AST	U/L	80	62 - 98	79
SGPT/ALT	U/L	37	0 - 40	24
Gamma GT	U/L	16	9 - 23	22
Amylase	U/L	31	22 - 40	79

<sup>a</sup> Hemoglobin of 93 g/L

## Bovine Hematology (Ranch A)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940295 Y103	# 930607 Gr18
<b>Red Blood Count</b>	x10 <sup>12</sup> /L	7.87	6.05 - 9.70	8.98	5.56
<b>Hemoglobin</b>	g/L	127	99 - 156	137	106
<b>Hematocrit</b>		0.36	0.27 - 0.44	0.37	0.30
<b>Mean corpuscular volume</b>	fL	45	34 - 56	41	53
<b>Mean corpuscular hemoglobin</b>	pg	16	13 - 19	15	19
<b>Mean corpuscular hemoglobin conc.</b>	g/L	356	329 - 382	370	360
<b>Red cell Distribution width</b>	%	23	5.4 - 41	17.7	8.6
<b>Platelets</b>	x10 <sup>9</sup> /L	425	189 - 662	580	365
<b>Mean Platelet volume</b>	fL	7.0	5.1 - 8.9	5.3	7.4
<b>White Blood Count</b>	x10 <sup>9</sup> /L	8.5	4.5 - 12.5	11.2	5.7
<b>Neutrophils Rel.</b>		0.21	0.05 - 0.37	0.59	0.53
<b>Abs.</b>	x10 <sup>9</sup> /L	1.76	0.22 - 4.59	6.6	3.0
<b>Bands Rel.</b>		0	0	0.01	-
<b>Abs.</b>	x10 <sup>9</sup> /L	0	0 - 0.05	0.1	-
<b>Lymphocytes Rel.</b>		0.70	0.48 - 0.93	0.39	0.41
<b>Abs.</b>	x10 <sup>9</sup> /L	6.0	2.2 - 11.61	4.4	2.3
<b>Monocytes Rel.</b>		0.04	0 - 0.08	-	0.01
<b>Abs.</b>	x10 <sup>9</sup> /L	0.30	0 - 1.03	-	0.06
<b>Eosinophils Rel.</b>		0.05	0 - 0.14	0.01	0.05
<b>Abs.</b>	x10 <sup>9</sup> /L	0.46	0 - 1.77	0.1	0.3
<b>Basophils Rel.</b>		0	0 - 0.01	-	-
<b>Abs.</b>	x10 <sup>9</sup> /L	0	0 - 0.08	-	-
<b>Fibrinogen</b>	g/L			2	1

Bovine Hematology (Ranch A)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940295	# 940307
<b>Red Blood Count</b>	$\times 10^{12}/L$	7.87	6.05 - 9.70		
Hemoglobin	g/L	127	99 - 156	93 <sup>a</sup>	
Hematocrit		0.36	0.27 - 0.44		
<b>Mean corpuscular volume</b>	fL	45	34 - 56		
<b>Mean corpuscular hemoglobin</b>	pg	16	13 - 19		
<b>Mean corpuscular hemoglobin conc.</b>	g/L	356	329 - 382		
<b>Red cell Distribution width</b>	%	23	5.4 - 41		
Platelets	$\times 10^9/L$	425	189 - 662		
<b>Mean Platelet volume</b>	fL	7.0	5.1 - 8.9		
<b>White Blood Count</b>	$\times 10^9/L$	8.5	4.5 - 12.5		
<b>Neutrophils Rel.</b>		0.21	0.05 - 0.37		0.34
<b>Abs.</b>	$\times 10^9/L$	1.76	0.22 - 4.59		
<b>Bands Rel.</b>		0	0		0.01
<b>Abs.</b>	$\times 10^9/L$	0	0 - 0.05		
<b>Lymphocytes Rel.</b>		0.70	0.48 - 0.93		0.61
<b>Abs.</b>	$\times 10^9/L$	6.0	2.2 - 11.61		
<b>Monocytes Rel.</b>		0.04	0 - 0.08		0.04
<b>Abs.</b>	$\times 10^9/L$	0.30	0 - 1.03		
<b>Eosinophils Rel.</b>		0.05	0 - 0.14		
<b>Abs.</b>	$\times 10^9/L$	0.46	0 - 1.77		
<b>Basophils Rel.</b>		0	0 - 0.01		
<b>Abs.</b>	$\times 10^9/L$	0	0 - 0.08		
<b>Fibrinogen</b>	g/L			3	13

<sup>a</sup> Unable to provide accurate results for other parameters due to age of samples

## Bovine Clinical Chemistry 94.04.26 (Ranch A)

Test	S.I. Unit	AEC Normals-Adults		# 940307 Calf D-82
		Mean	Range	
Glucose	mmol/L	4.8	3.1 - 6.4	4.6
BUN	mmol/L	8.1	6.6 - 9.6	5.3
Creatinine	µmol/L	165	138 - 192	71
Total Protein	g/L	77	72 - 82	66
Albumin	g/L	37	34 - 40	20
Calcium	mmol/L	2.45	2.26-2.64	1.82
Phosphorus	mmol/L	2.00	1.50-2.50	1.46
Magnesium	mmol/L	0.94	0.81-1.08	0.75
Alb/Glob ratio	g/L	0.92	0.80-1.05	0.43
Sodium	mmol/L	142	138 - 145	140
Potassium	mmol/L	4.1	3.5 - 4.7	5.7
Chloride	mmol/L	101	98 - 104	100
Iron	µmol/L	29	20 - 37	2
Iron BC	µmol/L	46	37 - 55	33
TIBC	µmol/L	75	57 - 92	35
Total Bilirubin	µmol/L	2	0 - 4	
Direct Bilirubin	µmol/L	0	0 - 1	
Alk. Phos.	U/L	149	0 - 312	83
LDH	U/L	1267	939 - 1595	1114
CPK	U/L	228	55 - 401	748
SGOT/AST	U/L	80	62 - 98	123
SGPT/ALT	U/L	37	0 - 40	20
Gamma GT	U/L	16	9 - 23	20
Amylase	U/L	31	22 - 40	42

## Bovine Clinical Chemistry (Ranch A)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940327 Yw 154 <sup>a</sup>	# 940328 GrD-11 <sup>b</sup>
CPK	U/L	228	55 - 401	92	80
LDH	U/L	1267	939 - 1595	528	712
SGOT/AST	U/L	80	62 - 98	33	40
SGPT/ALT	U/L	37	0 - 40	7	8
Alk. Phos.	U/L	149	0 - 312	259	362
Gamma GT	U/L	16	9 - 23	62	95
Total Bilirubin	µmol/L	2	0 - 4	3	2
Glucose	mmol/L	4.8	3.1 - 6.4	3.5	4.6
BUN	mmol/L	8.1	6.6 - 9.6	5.3	2.4
Creatinine	µmol/L	165	138 - 192	164	115
Uric acid	µmol/L		24 - 37	90	75
Calcium	mmol/L	2.45	2.26-2.64	2.60	2.58
Phosphorus	mmol/L	2.00	1.50-2.50	3.55	3.33
Magnesium	mmol/L	0.94	0.81-1.08	0.84	0.76
Total Protein	G/L		72 - 82	59	58
Albumin	G/L		34 - 40	28	25
Alb/Glob ratio		0.92	0.80-1.05	0.90	0.76
Sodium	mmol/L	142	138 - 145	140	142
Potassium	mmol/L	4.1	3.5 - 4.7	6.2	6.7
Chloride	mmol/L	101	98 - 104	99	101
Iron	µmol/L	29	20 - 37	10	20
Iron BC	µmol/L	46	37 - 55	69	57
TIBC	µmol/L	75	57 - 92	79	77
Amylase	U/L	31		80	91

<sup>a</sup> Dam is Gr 162 (940345)<sup>b</sup> Dam is Gr 122 (940339)

## Bovine Hematology (Ranch A)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940327 Y154	# 940328 GrD119
Red Blood Count	x10 <sup>12</sup> /L	7.87	6.05 - 9.70	7.68	7.05
Hemoglobin	g/L	127	99 - 156	115	107
Hematocrit		0.36	0.27 - 0.44	0.30	0.27
Mean corpuscular volume	fL	45	34 - 56	40	39
Mean corpuscular hemoglobin	pg	16	13 - 19	15	15
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	378	390
Red cell Distribution width	%	23	5.4 - 41	16.8	15.5
Platelets	x10 <sup>9</sup> /L	425	189 - 662	949	934
Mean Platelet volume	fL	7.0	5.1 - 8.9	4.6	5.6
White Blood Count	x10 <sup>9</sup> /L	8.5	4.5 - 12.5	10.5	10.2
Neutrophils Rel.		0.21	0.05 - 0.37	0.43	0.53
Abs.	x10 <sup>9</sup> /L	1.76	0.22 - 4.59	4.5	5.4
Bands Rel.		0	0	0.02	-
Abs.	x10 <sup>9</sup> /L	0	0 - 0.05	0.21	-
Lymphocytes Rel.		0.70	0.48 - 0.93	0.49	0.42
Abs.	x10 <sup>9</sup> /L	6.0	2.2 - 11.61	5.1	4.3
Monocytes Rel.		0.04	0 - 0.08	0.06	0.04
Abs.	x10 <sup>9</sup> /L	0.30	0 - 1.03	0.63	0.4
Eosinophils Rel.		0.05	0 - 0.14	-	-
Abs.	x10 <sup>9</sup> /L	0.46	0 - 1.77	-	-
Basophils Rel.		0	0 - 0.01	-	0.01
Abs.	x10 <sup>9</sup> /L	0	0 - 0.08	-	0.1
Fibrinogen	g/L			3	3

Bovine Clinical Chemistry (Ranch A)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940329 Yw 158 <sup>a</sup>	# 940330 Yw 155 <sup>b</sup>
CPK	U/L	228	55 - 401	57	114
LDH	U/L	1267	939 - 1595	705	652
SGOT/AST	U/L	80	62 - 98	40	42
SGPT/ALT	U/L	37	0 - 40	9	8
Alk. Phos.	U/L	149	0 - 312	614	195
Gamma GT	U/L	16	9 - 23	108	74
Total Bilirubin	µmol/L	2	0 - 4	5	6
Glucose	mmol/L	4.8	3.1 - 6.4	5.6	4.4
BUN	mmol/L	8.1	6.6 - 9.6	1.9	2.3
Creatinine	µmol/L	165	138 - 192	112	122
Uric acid	µmol/L		24 - 37	89	66
Calcium	mmol/L	2.45	2.26-2.64	2.73	2.61
Phosphorus	mmol/L	2.00	1.50-2.50	3.73	3.36
Magnesium	mmol/L	0.94	0.81-1.08	0.80	0.84
Total Protein	G/L		72 - 82	61	67
Albumin	G/L		34 - 40	27	27
Alb/Glob ratio		0.92	0.80-1.05	0.79	0.68
Sodium	mmol/L	142	138 - 145	142	142
Potassium	mmol/L	4.1	3.5 - 4.7	6.0	6.1
Chloride	mmol/L	101	98 - 104	99	100
Iron	µmol/L	29	20 - 37	79	41
Iron BC	µmol/L	46	37 - 55	10	29
TIBC	µmol/L	75	57 - 92	89	70
Amylase	U/L	31		63	68

<sup>a</sup> Dam is Gr 101 (940340)

<sup>b</sup> Dam is Bk 6 (940341)

## Bovine Hematology (Ranch A)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940329 Y158	# 940330 Y155
Red Blood Count	x10 <sup>12</sup> /L	7.87	6.05 - 9.70	7.10	8.51
Hemaglobin	g/L	127	99 - 156	109	130
Hematocrit		0.36	0.27 - 0.44	0.29	0.34
Mean corpuscular volume	fL	45	34 - 56	40	40
Mean corpuscular hemoglobin	pg	16	13 - 19	15	15
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	382	385
Red cell Distribution width	%	23	5.4 - 41	13.0	16.8
Platelets	x10 <sup>9</sup> /L	425	189 - 662	940	612
Mean Platelet volume	fL	7.0	5.1 - 8.9	5.7	5.7
White Blood Count	x10 <sup>9</sup> /L	8.5	4.5 - 12.5	14.4	11.0
Neutrophils Rel.		0.21	0.05 - 0.37	0.53	0.24
Abs.	x10 <sup>9</sup> /L	1.76	0.22 - 4.59	7.6	2.6
Bands Rel.		0	0	0.01	-
Abs.	x10 <sup>9</sup> /L	0	0 - 0.05	0.14	-
Lymphocytes Rel.		0.70	0.48 - 0.93	0.44	0.73
Abs.	x10 <sup>9</sup> /L	6.0	2.2 - 11.61	6.3	8.0
Monocytes Rel.		0.04	0 - 0.08	0.01	0.02
Abs.	x10 <sup>9</sup> /L	0.30	0 - 1.03	0.14	0.22
Eosinophils Rel.		0.05	0 - 0.14	-	-
Abs.	x10 <sup>9</sup> /L	0.46	0 - 1.77	-	-
Basophils Rel.		0	0 - 0.01	0.01	0.01
Abs.	x10 <sup>9</sup> /L	0	0 - 0.08	0.14	0.11
Fibrinogen	g/L			3	3

## Bovine Clinical Chemistry (Ranch A)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940331 Yw 160 <sup>a</sup>	# 940332 Yw 156 <sup>b</sup>
CPK	U/L	228	55 - 401	110	105
LDH	U/L	1267	939 - 1595	999	783
SGOT/AST	U/L	80	62 - 98	53	47
SGPT/ALT	U/L	37	0 - 40	19	8
Alk. Phos.	U/L	149	0 - 312	546	748
Gamma GT	U/L	16	9 - 23	91	50
Total Bilirubin	µmol/L	2	0 - 4	6	4
Glucose	mmol/L	4.8	3.1 - 6.4	8.4	6.8
BUN	mmol/L	8.1	6.6 - 9.6	2.9	2.4
Creatinine	µmol/L	165	138 - 192	99	110
Uric acid	µmol/L		24 - 37	73	67
Calcium	mmol/L	2.45	2.26-2.64	2.68	2.55
Phosphorus	mmol/L	2.00	1.50-2.50	3.11	3.32
Magnesium	mmol/L	0.94	0.81-1.08	0.97	0.78
Total Protein	G/L		72 - 82	46	66
Albumin	G/L		34 - 40	25	24
Alb/Glob ratio		0.92	0.80-1.05	1.19	0.57
Sodium	mmol/L	142	138 - 145	144	140
Potassium	mmol/L	4.1	3.5 - 4.7	5.9	5.5
Chloride	mmol/L	101	98 - 104	100	97
Iron	µmol/L	29	20 - 37	12	56
Iron BC	µmol/L	46	37 - 55	72	37
TIBC	µmol/L	75	57 - 92	84	93
Amylase	U/L	31		105	92

<sup>a</sup> Dam is Gr 211 (940342)<sup>b</sup> Dam is GR 106 (940050)

Bovine Hematology (Ranch A)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940331 Y160	# 940332 Y156
Red Blood Count	x10 <sup>12</sup> /L	7.87	6.05 - 9.70	5.97	7.46
Hemoglobin	g/L	127	99 - 156	92	115
Hematocrit		0.36	0.27 - 0.44	0.25	0.32
Mean corpuscular volume	fL	45	34 - 56	41	43
Mean corpuscular hemoglobin	pg	16	13 - 19	15	15
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	375	356
Red cell Distribution width	%	23	5.4 - 41	no result	12.3
Platelets	x10 <sup>9</sup> /L	425	189 - 662	1377	832
Mean Platelet volume	fL	7.0	5.1 - 8.9	4.7	5.1
White Blood Count	x10 <sup>9</sup> /L	8.5	4.5 - 12.5	10.1	7.5
Neutrophils Rel.		0.21	0.05 - 0.37	0.40	0.40
Abs.	x10 <sup>9</sup> /L	1.76	0.22 - 4.59	4.04	3.0
Bands Rel.		0	0	-	-
Abs.	x10 <sup>9</sup> /L	0	0 - 0.05	-	-
Lymphocytes Rel.		0.70	0.48 - 0.93	0.57	0.50
Abs.	x10 <sup>9</sup> /L	6.0	2.2 - 11.61	5.75	3.75
Monocytes Rel.		0.04	0 - 0.08	0.02	0.08
Abs.	x10 <sup>9</sup> /L	0.30	0 - 1.03	0.20	0.6
Eosinophils Rel.		0.05	0 - 0.14	0.01	0.01
Abs.	x10 <sup>9</sup> /L	0.46	0 - 1.77	0.10	0.8
Basophils Rel.		0	0 - 0.01	-	0.01
Abs.	x10 <sup>9</sup> /L	0	0 - 0.08	-	0.8
Fibrinogen	g/L			4	2

Bovine Clinical Chemistry (Ranch A)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940333 GrD-12 <sup>a</sup>	# 940334 GrD-11 <sup>b</sup>
CPK	U/L	228	55 - 401	80	52
LDH	U/L	1267	939 - 1595	751	680
SGOT/AST	U/L	80	62 - 98	45	38
SGPT/ALT	U/L	37	0 - 40	10	10
Alk. Phos.	U/L	149	0 - 312	418	227
Gamma GT	U/L	16	9 - 23	215	92
Total Bilirubin	µmol/L	2	0 - 4	6	4
Glucose	mmol/L	4.8	3.1 - 6.4	5.9	5.9
BUN	mmol/L	8.1	6.6 - 9.6	3.6	6.0
Creatinine	µmol/L	165	138 - 192	111	149
Uric acid	µmol/L		24 - 37	75	90
Calcium	mmol/L	2.45	2.26-2.64	2.83	2.70
Phosphorus	mmol/L	2.00	1.50-2.50	3.25	3.55
Magnesium	mmol/L	0.94	0.81-1.08	0.88	0.67
Total Protein	G/L		72 - 82	67	79
Albumin	G/L		34 - 40	25	21
Alb/Glob ratio		0.92	0.80-1.05	0.60	0.36
Sodium	mmol/L	142	138 - 145	140	141
Potassium	mmol/L	4.1	3.5 - 4.7	6.2	6.1
Chloride	mmol/L	101	98 - 104	97	94
Iron	µmol/L	29	20 - 37	33	2
Iron BC	µmol/L	46	37 - 55	47	67
TIBC	µmol/L	75	57 - 92	80	69
Amylase	U/L	31		60	85

<sup>a</sup> Dam is Gr 66 (911075)

<sup>b</sup> Dam is GR 18 (930607)

Bovine Hematology (Ranch A)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940333 GrD121	# 940334 GrD118
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70	8.99	7.72
Hemoglobin	g/L	127	99 - 156	136	125
Hematocrit		0.36	0.27 - 0.44	0.37	0.35
Mean corpuscular volume	fL	45	34 - 56	41	46
Mean corpuscular hemoglobin	pg	16	13 - 19	15	16
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	369	354
Red cell Distribution width	%	23	5.4 - 41	17.4	11.6
Platelets	$\times 10^9/L$	425	189 - 662	733	465
Mean Platelet volume	fL	7.0	5.1 - 8.9	6.0	6.2
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5	12.1	12.9
Neutrophils Rel.		0.21	0.05 - 0.37	0.38	0.34
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59	4.6	4.4
Bands Rel.		0	0	0.01	0.01
Abs.	$\times 10^9/L$	0	0 - 0.05	0.12	0.13
Lymphocytes Rel.		0.70	0.48 - 0.93	0.57	0.63
Abs.	$\times 10^9/L$	6.0	2.2 - 11.61	6.9	8.12
Monocytes Rel.		0.04	0 - 0.08	0.03	-
Abs.	$\times 10^9/L$	0.30	0 - 1.03	0.36	-
Eosinophils Rel.		0.05	0 - 0.14	0.01	0.02
Abs.	$\times 10^9/L$	0.46	0 - 1.77	0.12	0.26
Basophils Rel.		0	0 - 0.01	-	-
Abs.	$\times 10^9/L$	0	0 - 0.08	-	-
Fibrinogen	g/L			2	2

Bovine Clinical Chemistry (Ranch A)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940335 GrD-12 <sup>a</sup>	# 940336 GrD-12 <sup>b</sup>
CPK	U/L	228	55 - 401	126	79
LDH	U/L	1267	939 - 1595	719	696
SGOT/AST	U/L	80	62 - 98	41	43
SGPT/ALT	U/L	37	0 - 40	6	7
Alk. Phos.	U/L	149	0 - 312	524	798
Gamma GT	U/L	16	9 - 23	57	114
Total Bilirubin	µmol/L	2	0 - 4	4	5
Glucose	mmol/L	4.8	3.1 - 6.4	6.1	6.3
BUN	mmol/L	8.1	6.6 - 9.6	2.0	5.8
Creatinine	µmol/L	165	138 - 192	119	127
Uric acid	µmol/L		24 - 37	65	63
Calcium	mmol/L	2.45	2.26-2.64	2.56	2.36
Phosphorus	mmol/L	2.00	1.50-2.50	3.07	3.39
Magnesium	mmol/L	0.94	0.81-1.08	0.83	0.68
Total Protein	G/L		72 - 82	58	73
Albumin	G/L		34 - 40	25	26
Alb/Glob ratio		0.92	0.80-1.05	0.76	0.55
Sodium	mmol/L	142	138 - 145	141	143
Potassium	mmol/L	4.1	3.5 - 4.7	6.3	5.8
Chloride	mmol/L	101	98 - 104	100	98
Iron	µmol/L	29	20 - 37	32	39
Iron BC	µmol/L	46	37 - 55	44	72
TIBC	µmol/L	75	57 - 92	76	111
Amylase	U/L	31		93	82

<sup>a</sup> Dam is Gr 49 (940344)

<sup>b</sup> Dam is GR 45 (940343)

Bovine Hematology (Ranch A)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940335 GrD122	# 940336 GrD120
<b>Red Blood Count</b>	$\times 10^{12}/L$	7.87	6.05 - 9.70	7.55	7.16
<b>Hemoglobin</b>	g/L	127	99 - 156	113	105
<b>Hematocrit</b>		0.36	0.27 - 0.44	0.31	0.28
<b>Mean corpuscular volume</b>	fL	45	34 - 56	41	40
<b>Mean corpuscular hemoglobin</b>	pg	16	13 - 19	15	15
<b>Mean corpuscular hemoglobin conc.</b>	g/L	356	329 - 382	364	371
<b>Red cell Distribution width</b>	%	23	5.4 - 41	11.4 <sup>a</sup>	14.7
<b>Platelets</b>	$\times 10^9/L$	425	189 - 662	956	821
<b>Mean Platelet volume</b>	fL	7.0	5.1 - 8.9	4.8	5.8
<b>White Blood Count</b>	$\times 10^9/L$	8.5	4.5 - 12.5	11.0	8.4
<b>Neutrophils Rel.</b>		0.21	0.05 - 0.37	0.62	0.52
<b>Abs.</b>	$\times 10^9/L$	1.76	0.22 - 4.59	6.8	4.36
<b>Bands Rel.</b>		0	0	0.02	0.01
<b>Abs.</b>	$\times 10^9/L$	0	0 - 0.05	0.22	0.08
<b>Lymphocytes Rel.</b>		0.70	0.48 - 0.93	0.32	0.43
<b>Abs.</b>	$\times 10^9/L$	6.0	2.2 - 11.61	3.52	3.6
<b>Monocytes Rel.</b>		0.04	0 - 0.08	0.02	0.02
<b>Abs.</b>	$\times 10^9/L$	0.30	0 - 1.03	0.22	0.17
<b>Eosinophils Rel.</b>		0.05	0 - 0.14	0.01	0.01
<b>Abs.</b>	$\times 10^9/L$	0.46	0 - 1.77	0.11	0.08
<b>Basophils Rel.</b>		0	0 - 0.01	0.01	0.01
<b>Abs.</b>	$\times 10^9/L$	0	0 - 0.08	0.11	0.08
<b>Fibrinogen</b>	g/L			2	4

<sup>a</sup> Vacuolation of the neutrophils

Bovine Clinical Chemistry (Ranch A)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940337 Yw 161 <sup>a</sup>	# 940338 GrD-12 <sup>b</sup>
CPK	U/L	228	55 - 401	65	73
LDH	U/L	1267	939 - 1595	621	736
SGOT/AST	U/L	80	62 - 98	38	35
SGPT/ALT	U/L	37	0 - 40	12	13
Alk. Phos.	U/L	149	0 - 312	201	712
Gamma GT	U/L	16	9 - 23	29	266
Total Bilirubin	µmol/L	2	0 - 4	4	1
Glucose	mmol/L	4.8	3.1 - 6.4	5.1	7.0
BUN	mmol/L	8.1	6.6 - 9.6	5.0	7.8
Creatinine	µmol/L	165	138 - 192	122	118
Uric acid	µmol/L		24 - 37	29	40
Calcium	mmol/L	2.45	2.26-2.64	2.57	3.10
Phosphorus	mmol/L	2.00	1.50-2.50	2.09	3.52
Magnesium	mmol/L	0.94	0.81-1.08	0.80	0.91
Total Protein	G/L		72 - 82	44	74
Albumin	G/L		34 - 40	26	26
Alb/Glob ratio		0.92	0.80-1.05	1.44	0.54
Sodium	mmol/L	142	138 - 145	142	143
Potassium	mmol/L	4.1	3.5 - 4.7	5.6	5.9
Chloride	mmol/L	101	98 - 104	102	94
Iron	µmol/L	29	20 - 37	18	29
Iron BC	µmol/L	46	37 - 55	57	71
TIBC	µmol/L	75	57 - 92	75	100
Amylase	U/L	31		86	108

<sup>a</sup> Dam is Yw 103 (940295)

<sup>b</sup> Dam is GR 36 (940346)

Bovine Hematology (Ranch A)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940337 Y161	# 940338 D123
Red Blood Count	x10 <sup>12</sup> /L	7.87	6.05 - 9.70	5.14	7.90
Hemoglobin	g/L	127	99 - 156	97	125
Hematocrit		0.36	0.27 - 0.44	0.27	0.35
Mean corpuscular volume	fL	45	34 - 56	52	45
Mean corpuscular hemoglobin	pg	16	13 - 19	19	16
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	365	356
Red cell Distribution width	%	23	5.4 - 41	8.4	9.9
Platelets	x10 <sup>9</sup> /L	425	189 - 662	446	765
Mean Platelet volume	fL	7.0	5.1 - 8.9	5.1	5.6
White Blood Count	x10 <sup>9</sup> /L	8.5	4.5 - 12.5	5.2	10.8
Neutrophils Rel.		0.21	0.05 - 0.37	0.42	0.52
Abs.	x10 <sup>9</sup> /L	1.76	0.22 - 4.59	2.18	5.6
Bands Rel.		0	0	0.01	-
Abs.	x10 <sup>9</sup> /L	0	0 - 0.05	0.05	-
Lymphocytes Rel.		0.70	0.48 - 0.93	0.47	0.44
Abs.	x10 <sup>9</sup> /L	6.0	2.2 - 11.61	2.44	4.75
Monocytes Rel.		0.04	0 - 0.08	0.03	0.03
Abs.	x10 <sup>9</sup> /L	0.30	0 - 1.03	0.16	0.32
Eosinophils Rel.		0.05	0 - 0.14	0.07	0.01
Abs.	x10 <sup>9</sup> /L	0.46	0 - 1.77	0.36	0.11
Basophils Rel.		0	0 - 0.01	-	-
Abs.	x10 <sup>9</sup> /L	0	0 - 0.08	-	-
Fibrinogen	g/L			2	4

Bovine Hematology (Ranch A)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940339 Gr122	# 940340 Gr101
<b>Red Blood Count</b>	x10 <sup>12</sup> /L	7.87	6.05 - 9.70	4.91	5.84
<b>Hemoglobin</b>	g/L	127	99 - 156	91	118
<b>Hematocrit</b>		0.36	0.27 - 0.44	0.25	0.32
<b>Mean corpuscular volume</b>	fL	45	34 - 56	52	55
<b>Mean corpuscular hemoglobin</b>	pg	16	13 - 19	19	20
<b>Mean corpuscular hemoglobin conc.</b>	g/L	356	329 - 382	358	368
<b>Red cell Distribution width</b>	%	23	5.4 - 41	8.9	8.7
<b>Platelets</b>	x10 <sup>9</sup> /L	425	189 - 662	439	360
<b>Mean Platelet volume</b>	fL	7.0	5.1 - 8.9	7.4	7.4
<b>White Blood Count</b>	x10 <sup>9</sup> /L	8.5	4.5 - 12.5	7.1	6.7
<b>Neutrophils Rel.</b>		0.21	0.05 - 0.37	0.45	0.41
<b>Abs.</b>	x10 <sup>9</sup> /L	1.76	0.22 - 4.59	3.2	2.75
<b>Bands Rel.</b>		0	0	0.01	-
<b>Abs.</b>	x10 <sup>9</sup> /L	0	0 - 0.05	0.07	-
<b>Lymphocytes Rel.</b>		0.70	0.48 - 0.93	0.36	0.45
<b>Abs.</b>	x10 <sup>9</sup> /L	6.0	2.2 - 11.61	2.56	3.0
<b>Monocytes Rel.</b>		0.04	0 - 0.08	0.02	0.03
<b>Abs.</b>	x10 <sup>9</sup> /L	0.30	0 - 1.03	0.14	0.2
<b>Eosinophils Rel.</b>		0.05	0 - 0.14	0.14	0.11
<b>Abs.</b>	x10 <sup>9</sup> /L	0.46	0 - 1.77	0.99	0.73
<b>Basophils Rel.</b>		0	0 - 0.01	0.02	-
<b>Abs.</b>	x10 <sup>9</sup> /L	0	0 - 0.08	0.14	-
<b>Fibrinogen</b>	g/L			2	1

## Bovine Clinical Chemistry (Ranch A)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940340 Gr 101	# 940339 Gr 122
CPK	U/L	228	55 - 401	120	126
LDH	U/L	1267	939 - 1595	871	854
SGOT/AST	U/L	80	62 - 98	72	85
SGPT/ALT	U/L	37	0 - 40	26	17
Alk. Phos.	U/L	149	0 - 312	59	21
Gamma GT	U/L	16	9 - 23	19	16
Total Bilirubin	µmol/L	2	0 - 4	4	3
Glucose	mmol/L	4.8	3.1 - 6.4	4.7	4.2
BUN	mmol/L	8.1	6.6 - 9.6	2.4	4.1
Creatinine	µmol/L	165	138 - 192	149	132
Uric acid	µmol/L		24 - 37	49	42
Calcium	mmol/L	2.45	2.26-2.64	2.14	2.20
Phosphorus	mmol/L	2.00	1.50-2.50	1.15	0.95
Magnesium	mmol/L	0.94	0.81-1.08	0.69	0.75
Total Protein	G/L		72 - 82	74	74
Albumin	G/L		34 - 40	33	30
Alb/Glob ratio		0.92	0.80-1.05	0.80	0.68
Sodium	mmol/L	142	138 - 145	140	137
Potassium	mmol/L	4.1	3.5 - 4.7	3.3	4.2
Chloride	mmol/L	101	98 - 104	96	93
Iron	µmol/L	29	20 - 37	21	20
Iron BC	µmol/L	46	37 - 55	29	31
TIBC	µmol/L	75	57 - 92	50	51
Amylase	U/L	31		76	67

Bovine Hematology (Ranch A)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940341 B6	# 940342 Gr211
<b>Red Blood Count</b>	x10 <sup>12</sup> /L	7.87	6.05 - 9.70	6.59	4.81
<b>Hemoglobin</b>	g/L	127	99 - 156	116	94
<b>Hematocrit</b>		0.36	0.27 - 0.44	0.31	0.26
<b>Mean corpuscular volume</b>	fL	45	34 - 56	48	53
<b>Mean corpuscular hemoglobin</b>	pg	16	13 - 19	18	20
<b>Mean corpuscular hemoglobin conc.</b>	g/L	356	329 - 382	370	369
<b>Red cell Distribution width</b>	%	23	5.4 - 41	8.4	8.3
<b>Platelets</b>	x10 <sup>9</sup> /L	425	189 - 662	404	311
<b>Mean Platelet volume</b>	fL	7.0	5.1 - 8.9	6.8	6.3
<b>White Blood Count</b>	x10 <sup>9</sup> /L	8.5	4.5 - 12.5	7.7	4.8
<b>Neutrophils Rel.</b>		0.21	0.05 - 0.37	0.56	0.27 <sup>a</sup>
<b>Abs.</b>	x10 <sup>9</sup> /L	1.76	0.22 - 4.59	4.3	1.3
<b>Bands Rel.</b>		0	0	-	0.06
<b>Abs.</b>	x10 <sup>9</sup> /L	0	0 - 0.05	-	0.29
<b>Lymphocytes Rel.</b>		0.70	0.48 - 0.93	0.37	0.63
<b>Abs.</b>	x10 <sup>9</sup> /L	6.0	2.2 - 11.61	2.85	3.0
<b>Monocytes Rel.</b>		0.04	0 - 0.08	-	0.02
<b>Abs.</b>	x10 <sup>9</sup> /L	0.30	0 - 1.03	-	0.1
<b>Eosinophils Rel.</b>		0.05	0 - 0.14	0.05	0.02
<b>Abs.</b>	x10 <sup>9</sup> /L	0.46	0 - 1.77	0.39	0.1
<b>Basophils Rel.</b>		0	0 - 0.01	0.02	-
<b>Abs.</b>	x10 <sup>9</sup> /L	0	0 - 0.08	0.15	-
<b>Fibrinogen</b>	g/L			3	2

<sup>a</sup> Neutrophils appear hyposegmented

## Bovine Clinical Chemistry (Ranch A)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940342 Gr 21	# 940341 Bk 6
CPK	U/L	228	55 - 401	94	105
LDH	U/L	1267	939 - 1595	766	989
SGOT/AST	U/L	80	62 - 98	95	72
SGPT/ALT	U/L	37	0 - 40	14	27
Alk. Phos.	U/L	149	0 - 312	17	43
Gamma GT	U/L	16	9 - 23	20	22
Total Bilirubin	µmol/L	2	0 - 4	8	4
Glucose	mmol/L	4.8	3.1 - 6.4	5.1	4.1
BUN	mmol/L	8.1	6.6 - 9.6	3.7	3.3
Creatinine	µmol/L	165	138 - 192	133	169
Uric acid	µmol/L		24 - 37	33	42
Calcium	mmol/L	2.45	2.26-2.64	1.91	2.23
Phosphorus	mmol/L	2.00	1.50-2.50	1.16	1.02
Magnesium	mmol/L	0.94	0.81-1.08	0.35	1.80
Total Protein	G/L		72 - 82	74	76
Albumin	G/L		34 - 40	27	31
Alb/Glob ratio		0.92	0.80-1.05	0.57	0.69
Sodium	mmol/L	142	138 - 145	141	140
Potassium	mmol/L	4.1	3.5 - 4.7	3.1	3.9
Chloride	mmol/L	101	98 - 104	91	94
Iron	µmol/L	29	20 - 37	22	21
Iron BC	µmol/L	46	37 - 55	19	37
TIBC	µmol/L	75	57 - 92	41	58
Amylase	U/L	31		74	105

Bovine Hematology (Ranch A)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940343 Gr45	# 940344 Gr49
<b>Red Blood Count</b>	$\times 10^{12}/L$	7.87	6.05 - 9.70	5.71	8.44
<b>Hemoglobin</b>	g/L	127	99 - 156	114	141
<b>Hematocrit</b>		0.36	0.27 - 0.44	0.32	0.39
<b>Mean corpuscular volume</b>	fL	45	34 - 56	56	46
<b>Mean corpuscular hemoglobin</b>	pg	16	13 - 19	20	17
<b>Mean corpuscular hemoglobin conc.</b>	g/L	356	329 - 382	358	365
<b>Red cell Distribution width</b>	%	23	5.4 - 41	8.3	9.0
<b>Platelets</b>	$\times 10^9/L$	425	189 - 662	356	346
<b>Mean Platelet volume</b>	fL	7.0	5.1 - 8.9	8.1	7.1
<b>White Blood Count</b>	$\times 10^9/L$	8.5	4.5 - 12.5	10.8	9.2
<b>Neutrophils Rel.</b>		0.21	0.05 - 0.37	0.57	0.38
<b>Abs.</b>	$\times 10^9/L$	1.76	0.22 - 4.59	6.16	3.5
<b>Bands Rel.</b>		0	0	0.02	-
<b>Abs.</b>	$\times 10^9/L$	0	0 - 0.05	0.22	-
<b>Lymphocytes Rel.</b>		0.70	0.48 - 0.93	0.33	0.41
<b>Abs.</b>	$\times 10^9/L$	6.0	2.2 - 11.61	3.56	3.77
<b>Monocytes Rel.</b>		0.04	0 - 0.08	0.03	0.01
<b>Abs.</b>	$\times 10^9/L$	0.30	0 - 1.03	0.33	0.09
<b>Eosinophils Rel.</b>		0.05	0 - 0.14	0.05	0.20
<b>Abs.</b>	$\times 10^9/L$	0.46	0 - 1.77	0.55	1.84
<b>Basophils Rel.</b>		0	0 - 0.01	-	-
<b>Abs.</b>	$\times 10^9/L$	0	0 - 0.08	-	-
<b>Fibrinogen</b>	g/L			1	3

## Bovine Clinical Chemistry (Ranch A)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940344 Gr 49	# 940343 Gr 45
CPK	U/L	228	55 - 401	135	87
LDH	U/L	1267	939 - 1595	890	874
SGOT/AST	U/L	80	62 - 98	91	75
SGPT/ALT	U/L	37	0 - 40	28	26
Alk. Phos.	U/L	149	0 - 312	28	20
Gamma GT	U/L	16	9 - 23	12	15
Total Bilirubin	µmol/L	2	0 - 4	4	2
Glucose	mmol/L	4.8	3.1 - 6.4	4.3	3.6
BUN	mmol/L	8.1	6.6 - 9.6	2.5	2.4
Creatinine	µmol/L	165	138 - 192	193	143
Uric acid	µmol/L		24 - 37	73	51
Calcium	mmol/L	2.45	2.26-2.64	2.29	2.04
Phosphorus	mmol/L	2.00	1.50-2.50	0.91	0.78
Magnesium	mmol/L	0.94	0.81-1.08	0.61	0.61
Total Protein	G/L		72 - 82	71	72
Albumin	G/L		34 - 40	33	32
Alb/Glob ratio		0.92	0.80-1.05	0.87	0.80
Sodium	mmol/L	142	138 - 145	144	137
Potassium	mmol/L	4.1	3.5 - 4.7	4.8	3.5
Chloride	mmol/L	101	98 - 104	96	93
Iron	µmol/L	29	20 - 37	20	18
Iron BC	µmol/L	46	37 - 55	32	36
TIBC	µmol/L	75	57 - 92	52	54
Amylase	U/L	31		72	56

Bovine Hematology (Ranch A)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940345 Gr162	# 940346 Gr36
<b>Red Blood Count</b>	$\times 10^{12}/L$	7.87	6.05 - 9.70	6.05	4.71
<b>Hemoglobin</b>	g/L	127	99 - 156	109	93
<b>Hematocrit</b>		0.36	0.27 - 0.44	0.30	0.26
<b>Mean corpuscular volume</b>	fL	45	34 - 56	50	55
<b>Mean corpuscular hemoglobin</b>	pg	16	13 - 19	18	20
<b>Mean corpuscular hemoglobin conc.</b>	g/L	356	329 - 382	359	362
<b>Red cell Distribution width</b>	%	23	5.4 - 41	8.7	8.2
<b>Platelets</b>	$\times 10^9/L$	425	189 - 662	395	434
<b>Mean Platelet volume</b>	fL	7.0	5.1 - 8.9	6.3	6.1
<b>White Blood Count</b>	$\times 10^9/L$	8.5	4.5 - 12.5	4.0	6.4
<b>Neutrophils Rel.</b>		0.21	0.05 - 0.37	0.34	0.38
<b>Abs.</b>	$\times 10^9/L$	1.76	0.22 - 4.59	1.36	2.4
<b>Bands Rel.</b>		0	0	-	-
<b>Abs.</b>	$\times 10^9/L$	0	0 - 0.05	-	-
<b>Lymphocytes Rel.</b>		0.70	0.48 - 0.93	0.60	0.50
<b>Abs.</b>	$\times 10^9/L$	6.0	2.2 - 11.61	2.4	3.2
<b>Monocytes Rel.</b>		0.04	0 - 0.08	-	0.01
<b>Abs.</b>	$\times 10^9/L$	0.30	0 - 1.03	-	0.06
<b>Eosinophils Rel.</b>		0.05	0 - 0.14	0.06	0.10
<b>Abs.</b>	$\times 10^9/L$	0.46	0 - 1.77	0.24	0.6
<b>Basophils Rel.</b>		0	0 - 0.01	-	0.01
<b>Abs.</b>	$\times 10^9/L$	0	0 - 0.08	-	0.06
<b>Fibrinogen</b>	g/L			2	3

## Bovine Clinical Chemistry (Ranch A)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940346 Gr 36	# 940345 Gr 162
CPK	U/L	228	55 - 401	88	119
LDH	U/L	1267	939 - 1595	920	873
SGOT/AST	U/L	80	62 - 98	90	80
SGPT/ALT	U/L	37	0 - 40	25	20
Alk. Phos.	U/L	149	0 - 312	33	73
Gamma GT	U/L	16	9 - 23	17	18
Total Bilirubin	µmol/L	2	0 - 4	2	2
Glucose	mmol/L	4.8	3.1 - 6.4	4.2	4.0
BUN	mmol/L	8.1	6.6 - 9.6	4.0	2.2
Creatinine	µmol/L	165	138 - 192	172	201
Uric acid	µmol/L		24 - 37	24	48
Calcium	mmol/L	2.45	2.26-2.64	2.02	2.18
Phosphorus	mmol/L	2.00	1.50-2.50	1.21	1.26
Magnesium	mmol/L	0.94	0.81-1.08	0.79	0.66
Total Protein	G/L		72 - 82	69	78
Albumin	G/L		34 - 40	33	33
Alb/Glob ratio		0.92	0.80-1.05	0.92	0.73
Sodium	mmol/L	142	138 - 145	146	140
Potassium	mmol/L	4.1	3.5 - 4.7	4.0	3.6
Chloride	mmol/L	101	98 - 104	103	90
Iron	µmol/L	29	20 - 37	27	21
Iron BC	µmol/L	46	37 - 55	25	28
TIBC	µmol/L	75	57 - 92	52	49
Amylase	U/L	31		74	46

## Bovine Clinical Chemistry (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940119 <sup>a</sup> Calf 19	# 940120 <sup>b</sup> Calf 79
Glucose	mmol/L	4.8	3.1 - 6.4	4.9	6.6
BUN	mmol/L	8.1	6.6 - 9.6	8.9	5.8
Creatinine	µmol/L	165	138 - 192	106	92
Total Protein	g/L	77	72 - 82	51	48
Albumin	g/L	37	34 - 40	27	25
Calcium	mmol/L	2.45	2.26-2.64	2.63	3.03
Phosphorus	mmol/L	2.00	1.50-2.50	2.9	3.57
Magnesium	mmol/L	0.94	0.81-1.08	0.87	0.87
Alb/Glob ratio		0.92	0.80-1.05	1.13	1.09
Sodium	mmol/L	142	138 - 145	138	136
Potassium	mmol/L	4.1	3.5 - 4.7	5.9	5.8
Chloride	mmol/L	101	98 - 104	100	93
Iron	µmol/L	29	20 - 37	12	9
Iron BC	µmol/L	46	37 - 55	78	75
TIBC	µmol/L	75	57 - 92	90	84
Total Bilirubin	µmol/L	2	0 - 4		2
Direct Bilirubin	µmol/L	0	0 - 1		
Alk. Phos.	U/L	149	0 - 312	271	281
LDH	U/L	1267	939 - 1595	1380	761
CPK	U/L	228	55 - 401	2210	116
SGOT/AST	U/L	80	62 - 98	202	45
SGPT/ALT	U/L	37	0 - 40	116	11
Gamma GT	U/L	16	9 - 23	86	42
Amylase	U/L	31	22 - 40	80	60

<sup>a</sup> Moderate hemolysis<sup>b</sup> Moderate lipemia

Bovine Hematology (Ranch B)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940119 Calf 19	# 940120 Calf 79
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70	7.06	7.19
Hemoglobin	g/L	127	99 - 156	103	103
Hematocrit		0.36	0.27 - 0.44	0.29	0.30
Mean corpuscular volume	fL	45	34 - 56	41	41
Mean corpuscular hemoglobin	pg	16	13 - 19	15	14
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	359	349
Red cell Distribution width	%	23	5.4 - 41	10.9	13.6 <sup>d</sup>
Platelets	$\times 10^9/L$	425	189 - 662	447 <sup>a</sup>	935
Mean Platelet volume	fL	7.0	5.1 - 8.9	4.9	5.6
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5	10.7	10.2
Neutrophils Rel.		0.21	0.05 - 0.37	0.18	0.36
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59	1.92	3.67
Bands Rel.		0	0	0.35 <sup>b</sup>	0.1
Abs.	$\times 10^9/L$	0	0 - 0.05	3.75	1.0
Lymphocytes Rel.		0.70	0.48 - 0.93	0.20 <sup>c</sup>	0.46
Abs.	$\times 10^9/L$	6.0	2.2 - 11.61	2.14	4.69
Monocytes Rel.		0.04	0 - 0.08	0.03	0.05
Abs.	$\times 10^9/L$	0.30	0 - 1.03	0.32	0.51
Eosinophils Rel.		0.05	0 - 0.14	-	0.01
Abs.	$\times 10^9/L$	0.46	0 - 1.77	-	0.10
Basophils Rel.		0	0 - 0.01	0.01	-
Abs.	$\times 10^9/L$	0	0 - 0.08	0.10	-
Fibrinogen	g/L			5	5

<sup>a</sup> No platelets observed on differential smear

<sup>b</sup> Consists of blast cells, metamyelocytes, myelocytes, and some degenerative white blood cells

<sup>c</sup> Moderate atypical lymphocytes (reactive)

<sup>d</sup> Appear increased, numerous large forms

Bovine Clinical Chemistry (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940121 <sup>a</sup> Calf 83	# 940122 Calf 98
Glucose	mmol/L	4.8	3.1 - 6.4	6.5	5.2
BUN	mmol/L	8.1	6.6 - 9.6	5.7	6.5
Creatinine	µmol/L	165	138 - 192	144	96
Total Protein	g/L	77	72 - 82	50	54
Albumin	g/L	37	34 - 40	25	25
Calcium	mmol/L	2.45	2.26-2.64	2.71	3.03
Phosphorus	mmol/L	2.00	1.50-2.50	2.18	3.40
Magnesium	mmol/L	0.94	0.81-1.08	0.95	0.75
Alb/Glob ratio		0.92	0.80-1.05	1.00	0.86
Sodium	mmol/L	142	138 - 145	139	132
Potassium	mmol/L	4.1	3.5 - 4.7	5.5	5.9
Chloride	mmol/L	101	98 - 104	95	88
Iron	µmol/L	29	20 - 37	20	3
Iron BC	µmol/L	46	37 - 55	40	77
TIBC	µmol/L	75	57 - 92	60	80
Total Bilirubin	µmol/L	2	0 - 4	29	7
Direct Bilirubin	µmol/L	0	0 - 1	8	
Alk. Phos.	U/L	149	0 - 312	77	201
LDH	U/L	1267	939 - 1595	877	638
CPK	U/L	228	55 - 401	297	108
SGOT/AST	U/L	80	62 - 98	82	47
SGPT/ALT	U/L	37	0 - 40	13	15
Gamma GT	U/L	16	9 - 23	95	152
Amylase	U/L	31	22 - 40	45	149

<sup>a</sup> Slight icterus

### Bovine Hematology (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940121 Calf 83	# 940122 Calf 98
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70	6.38	4.36
Hemoglobin	g/L	127	99 - 156	84	64
Hematocrit		0.36	0.27 - 0.44	0.27	0.18
Mean corpuscular volume	fL	45	34 - 56	42	41
Mean corpuscular hemoglobin	pg	16	13 - 19	13	15
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	317	361
Red cell Distribution width	%	23	5.4 - 41	10.2	11.6
Platelets	$\times 10^9/L$	425	189 - 662	488	1124
Mean Platelet volume	fL	7.0	5.1 - 8.9	6.3	5.4
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5	5.7	8.2
Neutrophils Rel.		0.21	0.05 - 0.37	0.64	0.19
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59	3.64	1.55
Bands Rel.		0	0	0.10	0.05
Abs.	$\times 10^9/L$	0	0 - 0.05	0.57	0.41
Lymphocytes Rel.		0.70	0.48 - 0.93	0.20	0.76 <sup>a</sup>
Abs.	$\times 10^9/L$	6.0	2.2 - 11.61	1.14	6.23
Monocytes Rel.		0.04	0 - 0.08	0.04	-
Abs.	$\times 10^9/L$	0.30	0 - 1.03	0.22	-
Eosinophils Rel.		0.05	0 - 0.14	0.01	-
Abs.	$\times 10^9/L$	0.46	0 - 1.77	0.06	-
Basophils Rel.		0	0 - 0.01	0.01	-
Abs.	$\times 10^9/L$	0	0 - 0.08	0.06	-
Fibrinogen	g/L			3	4

<sup>a</sup> Most are atypical lymphocytes

Bovine Clinical Chemistry (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940123 Calf 123	# 940124 Calf 144
Glucose	mmol/L	4.8	3.1 - 6.4	2.1	6.7
BUN	mmol/L	8.1	6.6 - 9.6	3.5	4.4
Creatinine	µmol/L	165	138 - 192	423	65
Total Protein	g/L	77	72 - 82	41	47
Albumin	g/L	37	34 - 40	23	27
Calcium	mmol/L	2.45	2.26-2.64	3.07	2.83
Phosphorus	mmol/L	2.00	1.50-2.50	2.18	2.49
Magnesium	mmol/L	0.94	0.81-1.08	0.96	0.74
Alb/Glob ratio		0.92	0.80-1.05	1.28	1.35
Sodium	mmol/L	142	138 - 145	139	123
Potassium	mmol/L	4.1	3.5 - 4.7	5.9	5.5
Chloride	mmol/L	101	98 - 104	94	84
Iron	µmol/L	29	20 - 37	40	1
Iron BC	µmol/L	46	37 - 55	18	78
TIBC	µmol/L	75	57 - 92	58	79
Total Bilirubin	µmol/L	2	0 - 4	15	3
Direct Bilirubin	µmol/L	0	0 - 1	7	
Alk. Phos.	U/L	149	0 - 312	772	116
LDH	U/L	1267	939 - 1595	3390	627
CPK	U/L	228	55 - 401	21640	138
SGOT/AST	U/L	80	62 - 98	300	35
SGPT/ALT	U/L	37	0 - 40	70	11
Gamma GT	U/L	16	9 - 23	15	20
Amylase	U/L	31	22 - 40	46	82

Bovine Hematology (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940123 Calf 123	# 940124 Calf 144
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70	8.34	4.33
Hemoglobin	g/L	127	99 - 156	122	65
Hematocrit		0.36	0.27 - 0.44	0.36	0.17
Mean corpuscular volume	fL	45	34 - 56	43	38
Mean corpuscular hemoglobin	pg	16	13 - 19	15	15
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	340	395
Red cell Distribution width	%	23	5.4 - 41	11.2	13.0
Platelets	$\times 10^9/L$	425	189 - 662	553	-
Mean Platelet volume	fL	7.0	5.1 - 8.9	6.4	-
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5	12.7	10.9
Neutrophils Rel.		0.21	0.05 - 0.37	0.68	0.55
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59	8.64	5.99
Bands Rel.		0	0	0.09	0.02
Abs.	$\times 10^9/L$	0	0 - 0.05	1.14	0.21
Lymphocytes Rel.		0.70	0.48 - 0.93	0.14	0.43
Abs.	$\times 10^9/L$	6.0	2.2 - 11.61	1.78	4.68
Monocytes Rel.		0.04	0 - 0.08	0.09	-
Abs.	$\times 10^9/L$	0.30	0 - 1.03	1.14	-
Eosinophils Rel.		0.05	0 - 0.14	-	-
Abs.	$\times 10^9/L$	0.46	0 - 1.77	-	-
Basophils Rel.		0	0 - 0.01	-	-
Abs.	$\times 10^9/L$	0	0 - 0.08	-	-
Fibrinogen	g/L			1	3

Bovine Clinical Chemistry (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940136 Calf 98	# 940137 Calf 46
Glucose	mmol/L	4.8	3.1 - 6.4	6.7	5.6
BUN	mmol/L	8.1	6.6 - 9.6	14.5	3.0
Creatinine	µmol/L	165	138 - 192	106	110
Total Protein	g/L	77	72 - 82	45	57
Albumin	g/L	37	34 - 40	24	23
Calcium	mmol/L	2.45	2.26-2.64	2.61	2.70
Phosphorus	mmol/L	2.00	1.50-2.50	3.77	2.74
Magnesium	mmol/L	0.94	0.81-1.08	0.97	0.73
Alb/Glob ratio		0.92	0.80-1.05	1.14	0.68
Sodium	mmol/L	142	138 - 145	158	139
Potassium	mmol/L	4.1	3.5 - 4.7	6.1	5.3
Chloride	mmol/L	101	98 - 104	119	96
Iron	µmol/L	29	20 - 37	33	9
Iron BC	µmol/L	46	37 - 55	53	70
TIBC	µmol/L	75	57 - 92	86	79
Total Bilirubin	µmol/L	2	0 - 4	9	2
Direct Bilirubin	µmol/L	0	0 - 1		
Alk. Phos.	U/L	149	0 - 312	252	356
LDH	U/L	1267	939 - 1595	526	833
CPK	U/L	228	55 - 401	622	117
SGOT/AST	U/L	80	62 - 98	52	60
SGPT/ALT	U/L	37	0 - 40	19	14
Gamma GT	U/L	16	9 - 23	60	259
Amylase	U/L	31	22 - 40	120	95

Bovine Hematology (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940137 Calf 46	# 940136 Calf 98
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70	7.86	3.63
Hemoglobin	g/L	127	99 - 156	119	57
Hematocrit		0.36	0.27 - 0.44	0.34	0.15
Mean corpuscular volume	fL	45	34 - 56	43	41
Mean corpuscular hemoglobin	pg	16	13 - 19	15	16
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	355	384
Red cell Distribution width	%	23	5.4 - 41	10.2	11.5
Platelets	$\times 10^9/L$	425	189 - 662	399	-
Mean Platelet volume	fL	7.0	5.1 - 8.9	5.5	-
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5	10.9	12.1
Neutrophils Rel.		0.21	0.05 - 0.37	0.38	0.51
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59	4.14	6.17
Bands Rel.		0	0	-	-
Abs.	$\times 10^9/L$	0	0 - 0.05	-	-
Lymphocytes Rel.		0.70	0.48 - 0.93	0.56	0.45
Abs.	$\times 10^9/L$	6.0	2.2 - 11.61	6.10	5.44
Monocytes Rel.		0.04	0 - 0.08	0.03	0.02
Abs.	$\times 10^9/L$	0.30	0 - 1.03	0.33	0.24
Eosinophils Rel.		0.05	0 - 0.14	0.01	-
Abs.	$\times 10^9/L$	0.46	0 - 1.77	0.11	-
Basophils Rel.		0	0 - 0.01	0.01	-
Abs.	$\times 10^9/L$	0	0 - 0.08	0.11	-
Fibrinogen	g/L			3	-

Hematology on EDTA blood using Coulter SPlus IV

Bovine Clinical Chemistry (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940237 Calf 2	# 940238 Calf 8
<b>Glucose</b>	mmol/L	4.8	3.1 - 6.4	2.8	11.0
<b>BUN</b>	mmol/L	8.1	6.6 - 9.6	2.7	22.3
<b>Creatinine</b>	µmol/L	165	138 - 192	82	113
<b>Total Protein</b>	g/L	77	72 - 82	60	68
<b>Albumin</b>	g/L	37	34 - 40	24	25
<b>Calcium</b>	mmol/L	2.45	2.26-2.64	2.16	2.33
<b>Phosphorus</b>	mmol/L	2.00	1.50-2.50	1.81	3.52
<b>Magnesium</b>	mmol/L	0.94	0.81-1.08	0.79	1.21
<b>Alb/Glob ratio</b>		0.92	0.80-1.05	0.67	0.58
<b>Sodium</b>	mmol/L	142	138 - 145	144	155
<b>Potassium</b>	mmol/L	4.1	3.5 - 4.7	4.1	5.2
<b>Chloride</b>	mmol/L	101	98 - 104	109	114
<b>Iron</b>	µmol/L	29	20 - 37	3	6
<b>Iron BC</b>	µmol/L	46	37 - 55	65	41
<b>TIBC</b>	µmol/L	75	57 - 92	68	47
<b>Total Bilirubin</b>	µmol/L	2	0 - 4	25	6
<b>Direct Bilirubin</b>	µmol/L	0	0 - 1	6	1
<b>Alk. Phos.</b>	U/L	149	0 - 312	83	184
<b>LDH</b>	U/L	1267	939 - 1595	637	768
<b>CPK</b>	U/L	228	55 - 401	66	443
<b>SGOT/AST</b>	U/L	80	62 - 98	48	99
<b>SGPT/ALT</b>	U/L	37	0 - 40	10	16
<b>Gamma GT</b>	U/L	16	9 - 23	28	48
<b>Amylase</b>	U/L	31	22 - 40	51	165

Bovine Hematology (Ranch B)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940237 Calf 2	# 940238 Calf 8
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70		
Hemoglobin	g/L	127	99 - 156		
Hematocrit		0.36	0.27 - 0.44		
Mean corpuscular volume	fL	45	34 - 56		
Mean corpuscular hemoglobin	pg	16	13 - 19		
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382		
Red cell Distribution width	%	23	5.4 - 41		
Platelets	$\times 10^9/L$	425	189 - 662		
Mean Platelet volume	fL	7.0	5.1 - 8.9		
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5		
Neutrophils Rel.		0.21	0.05 - 0.37		
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59		
Bands Rel.		0	0		
Abs.	$\times 10^9/L$	0	0 - 0.05		
Lymphocytes Rel.		0.70	0.48 - 0.93		
Abs.	$\times 10^9/L$	6.0	2.2 - 11.61		
Monocytes Rel.		0.04	0 - 0.08		
Abs.	$\times 10^9/L$	0.30	0 - 1.03		
Eosinophils Rel.		0.05	0 - 0.14		
Abs.	$\times 10^9/L$	0.46	0 - 1.77		
Basophils Rel.		0	0 - 0.01		
Abs.	$\times 10^9/L$	0	0 - 0.08		
Fibrinogen	g/L				

Bovine Hematology (Ranch B)

Test	S.I.Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940237 Calf 2	# 940238 Calf 8
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70	4.16 <sup>a</sup>	8.85
Hemoglobin	g/L	127	99 - 156	71	127
Hematocrit		0.36	0.27 - 0.44	0.16	0.38
Mean corpuscular volume	fL	45	34 - 56	37	43
Mean corpuscular hemoglobin	pg	16	13 - 19	17	14
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	459	331
Red cell Distribution width	%	23	5.4 - 41	15.5	13.1
Platelets	$\times 10^9/L$	425	189 - 662	- <sup>b</sup>	1138
Mean Platelet volume	fL	7.0	5.1 - 8.9	- <sup>b</sup>	5.1
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5	12.3	25.4
Neutrophils Rel.		0.21	0.05 - 0.37	0.39	0.75
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59	4.79	19.1
Bands Rel.		0	0	0.06	0.07
Abs.	$\times 10^9/L$	0	0 - 0.05	0.74	1.78
Lymphocytes Rel.		0.70	0.48 - 0.93	0.34	0.11
Abs.	$\times 10^9/L$	6.0	2.2 - 11.61	4.18	2.79
Monocytes Rel.		0.04	0 - 0.08	0.20 <sup>c</sup>	0.07
Abs.	$\times 10^9/L$	0.30	0 - 1.03	2.46	1.78
Eosinophils Rel.		0.05	0 - 0.14	-	-
Abs.	$\times 10^9/L$	0.46	0 - 1.77	-	-
Basophils Rel.		0	0 - 0.01	-	-
Abs.	$\times 10^9/L$	0	0 - 0.08	-	-
Fibrinogen	g/L			15	15

<sup>a</sup> Not all cells may have been counted due to their small size

<sup>b</sup> Unable to obtain results

<sup>c</sup> Monocytes have very little vacuolation, quite large

## Bovine Clinical Chemistry (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID
		Mean	Range	# 940278 22B
CPK	U/L	228	55 - 401	126
LDH	U/L	1267	939 - 1595	1602
SGOT/AST	U/L	80	62 - 98	70
SGPT/ALT	U/L	37	0 - 40	8
Alk. Phos.	U/L	149	0 - 312	72
Gamma GT	U/L	16	9 - 23	38
Total Bilirubin	µmol/L	2	0 - 4	2
Glucose	mmol/L	4.8	3.1 - 6.4	2.5
BUN	mmol/L	8.1	6.6 - 9.6	17.0
Creatinine	µmol/L	165	138 - 192	125
Uric acid	µmol/L		24 - 37	73
Calcium	mmol/L	2.45	2.26-2.64	2.04
Phosphorus	mmol/L	2.00	1.50-2.50	2.19
Magnesium	mmol/L	0.94	0.81-1.08	0.91
Total Protein	G/L		72 - 82	74
Albumin	G/L		34 - 40	22
Alb/Glob ratio		0.92	0.80-1.05	0.42
Sodium	mmol/L	142	138 - 145	134
Potassium	mmol/L	4.1	3.5 - 4.7	4.8
Chloride	mmol/L	101	98 - 104	98
Iron	µmol/L	29	20 - 37	21
Iron BC	µmol/L	46	37 - 55	39
TIBC	µmol/L	75	57 - 92	60
Amylase	U/L	31		29

Bovine Hematology (Ranch B)

Test	S.I. Unit	AEC Normals -Adults		# 940278
		Mean	Range	
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70	5.09
Hemoglobin	g/L	127	99 - 156	88
Hematocrit		0.36	0.27 - 0.44	0.27
Mean corpuscular volume	fL	45	34 - 56	52
Mean corpuscular hemoglobin	pg	16	13 - 19	17
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	330
Red cell Distribution width	%	23	5.4 - 41	-
Platelets	$\times 10^9/L$	425	189 - 662	-
Mean Platelet volume	fL	7.0	5.1 - 8.9	-
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5	8.1
Neutrophils Rel.		0.21	0.05 - 0.37	0.38
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59	3.08
Bands Rel.		0	0	0.01
Abs.	$\times 10^9/L$	0	0 - 0.05	0.08
Lymphocytes Rel.		0.70	0.48 - 0.93	0.59
Abs.	$\times 10^9/L$	6.0	2.2 - 11.61	4.78
Monocytes Rel.		0.04	0 - 0.08	0.01
Abs.	$\times 10^9/L$	0.30	0 - 1.03	0.08
Eosinophils Rel.		0.05	0 - 0.14	0.01
Abs.	$\times 10^9/L$	0.46	0 - 1.77	0.08
Basophils Rel.		0	0 - 0.01	-
Abs.	$\times 10^9/L$	0	0 - 0.08	-
Fibrinogen	g/L			2

## Bovine Clinical Chemistry (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID
		Mean	Range	# 940299 Wh 84
CPK	U/L	228	55 - 401	601
LDH	U/L	1267	939 - 1595	1144
SGOT/AST	U/L	80	62 - 98	81
SGPT/ALT	U/L	37	0 - 40	36
Alk. Phos.	U/L	149	0 - 312	98
Gamma GT	U/L	16	9 - 23	17
Total Bilirubin	µmol/L	2	0 - 4	< 1
Glucose	mmol/L	4.8	3.1 - 6.4	36.5
BUN	mmol/L	8.1	6.6 - 9.6	28.8
Creatinine	µmol/L	165	138 - 192	348
Uric acid	µmol/L		24 - 37	121
Calcium	mmol/L	2.45	2.26-2.64	2.46
Phosphorus	mmol/L	2.00	1.50-2.50	2.14
Magnesium	mmol/L	0.94	0.81-1.08	1.45
Total Protein	G/L		72 - 82	97
Albumin	G/L		34 - 40	39
Alb/Glob ratio		0.92	0.80-1.05	0.67
Sodium	mmol/L	142	138 - 145	131
Potassium	mmol/L	4.1	3.5 - 4.7	3.9
Chloride	mmol/L	101	98 - 104	90
Iron	µmol/L	29	20 - 37	10
Iron BC	µmol/L	46	37 - 55	49
TIBC	µmol/L	75	57 - 92	59
Amylase	U/L	31		173

Bovine Clinical Chemistry (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940311 BT 170	# 940312 BT61 Blue
CPK	U/L	228	55 - 401	269	160
LDH	U/L	1267	939 - 1595	1608	1132
SGOT/AST	U/L	80	62 - 98	111	86
SGPT/ALT	U/L	37	0 - 40	32	18
Alk. Phos.	U/L	149	0 - 312	40	68
Gamma GT	U/L	16	9 - 23	14	20
Total Bilirubin	µmol/L	2	0 - 4	< 1	2
Glucose	mmol/L	4.8	3.1 - 6.4	4.7	4.3
BUN	mmol/L	8.1	6.6 - 9.6	2.9	2.4
Creatinine	µmol/L	165	138 - 192	145	130
Uric acid	µmol/L		24 - 37	41	51
Calcium	mmol/L	2.45	2.26-2.64	2.31	2.36
Phosphorus	mmol/L	2.00	1.50-2.50	1.61	1.31
Magnesium	mmol/L	0.94	0.81-1.08	1.92	0.81
Total Protein	G/L		72 - 82	84	78
Albumin	G/L		34 - 40	34	29
Alb/Glob ratio		0.92	0.80-1.05	0.68	0.59
Sodium	mmol/L	142	138 - 145	141	140
Potassium	mmol/L	4.1	3.5 - 4.7	3.9	4.4
Chloride	mmol/L	101	98 - 104	98	100
Iron	µmol/L	29	20 - 37	29	19
Iron BC	µmol/L	46	37 - 55	26	31
TIBC	µmol/L	75	57 - 92	55	50
Amylase	U/L	31		85	102

Bovine Hematology (Ranch B)

Test	S.I.Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940311 BT170	# 940312 BT61Blue
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70	6.97	7.30
Hemoglobin	g/L	127	99 - 156	133	126
Hematocrit		0.36	0.27 - 0.44	0.37	0.35
Mean corpuscular volume	fL	45	34 - 56	53	48
Mean corpuscular hemoglobin	pg	16	13 - 19	19	17
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	362	362
Red cell Distribution width	%	23	5.4 - 41	8.8	8.6
Platelets	$\times 10^9/L$	425	189 - 662	401	590
Mean Platelet volume	fL	7.0	5.1 - 8.9	7.0	7.0
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5	6.5	9.9
Neutrophils Rel.		0.21	0.05 - 0.37	0.32	0.30
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59	2.08	2.97
Bands Rel.		0	0	0.01	-
Abs.	$\times 10^9/L$	0	0 - 0.05	0.07	-
Lymphocytes Rel.		0.70	0.48 - 0.93	0.46	0.49
Abs.	$\times 10^9/L$	6.0	2.2 - 11.61	2.99	4.85
Monocytes Rel.		0.04	0 - 0.08	0.07	0.04
Abs.	$\times 10^9/L$	0.30	0 - 1.03	0.46	0.40
Eosinophils Rel.		0.05	0 - 0.14	0.13	0.16
Abs.	$\times 10^9/L$	0.46	0 - 1.77	0.85	1.58
Basophils Rel.		0	0 - 0.01	0.01	0.01
Abs.	$\times 10^9/L$	0	0 - 0.08	0.07	0.99
Fibrinogen	g/L			2	2

Bovine Clinical Chemistry (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940313 BT 15	# 940314 BT 89
<b>CPK</b>	U/L	228	55 - 401	142	126
<b>LDH</b>	U/L	1267	939 - 1595	1704	992
<b>SGOT/AST</b>	U/L	80	62 - 98	107	74
<b>SGPT/ALT</b>	U/L	37	0 - 40	28	18
<b>Alk. Phos.</b>	U/L	149	0 - 312	155	57
<b>Gamma GT</b>	U/L	16	9 - 23	20	17
<b>Total Bilirubin</b>	µmol/L	2	0 - 4	3	7
<b>Glucose</b>	mmol/L	4.8	3.1 - 6.4	4.8	3.8
<b>BUN</b>	mmol/L	8.1	6.6 - 9.6	3.8	1.6
<b>Creatinine</b>	µmol/L	165	138 - 192	123	108
<b>Uric acid</b>	µmol/L		24 - 37	69	49
<b>Calcium</b>	mmol/L	2.45	2.26-2.64	2.51	2.06
<b>Phosphorus</b>	mmol/L	2.00	1.50-2.50	2.12	1.53
<b>Magnesium</b>	mmol/L	0.94	0.81-1.08	0.76	0.92
<b>Total Protein</b>	G/L		72 - 82	76	77
<b>Albumin</b>	G/L		34 - 40	34	29
<b>Alb/Glob ratio</b>		0.92	0.80-1.05	0.81	0.60
<b>Sodium</b>	mmol/L	142	138 - 145	144	141
<b>Potassium</b>	mmol/L	4.1	3.5 - 4.7	4.3	4.4
<b>Chloride</b>	mmol/L	101	98 - 104	100	96
<b>Iron</b>	µmol/L	29	20 - 37	45	18
<b>Iron BC</b>	µmol/L	46	37 - 55	15	31
<b>TIBC</b>	µmol/L	75	57 - 92	60	49
<b>Amylase</b>	U/L	31		111	74

## Bovine Hematology (Ranch B)

Test	S.I.Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940313 BT15	# 940314 BT89
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70	6.48	5.67
Hemaglobin	g/L	127	99 - 156	125	109
Hematocrit		0.36	0.27 - 0.44	0.34	0.30
Mean corpuscular volume	fL	45	34 - 56	52	53
Mean corpuscular hemoglobin	pg	16	13 - 19	19	19
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	370	365
Red cell Distribution width	%	23	5.4 - 41	8.6	8.5
Platelets	$\times 10^9/L$	425	189 - 662	344	254
Mean Platelet volume	fL	7.0	5.1 - 8.9	7.8	7.0
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5	7.2	7.9
Neutrophils Rel.		0.21	0.05 - 0.37	0.36	0.27
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59	2.59	2.13
Bands Rel.		0	0	-	0.03
Abs.	$\times 10^9/L$	0	0 - 0.05	-	0.24
Lymphocytes Rel.		0.70	0.48 - 0.93	0.50	0.36
Abs.	$\times 10^9/L$	6.0	2.2 - 11.61	3.60	2.84
Monocytes Rel.		0.04	0 - 0.08	0.03	0.03
Abs.	$\times 10^9/L$	0.30	0 - 1.03	0.22	0.24
Eosinophils Rel.		0.05	0 - 0.14	0.10	0.30
Abs.	$\times 10^9/L$	0.46	0 - 1.77	0.72	2.37
Basophils Rel.		0	0 - 0.01	0.01	0.01
Abs.	$\times 10^9/L$	0	0 - 0.08	0.07	0.08
Fibrinogen	g/L			1	6

Bovine Clinical Chemistry (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940315 BT 64	# 940316 BT 153
CPK	U/L	228	55 - 401	143	108
LDH	U/L	1267	939 - 1595	1100	987
SGOT/AST	U/L	80	62 - 98	86	79
SGPT/ALT	U/L	37	0 - 40	30	23
Alk. Phos.	U/L	149	0 - 312	68	117
Gamma GT	U/L	16	9 - 23	22	13
Total Bilirubin	µmol/L	2	0 - 4	2	3
Glucose	mmol/L	4.8	3.1 - 6.4	4.6	3.6
BUN	mmol/L	8.1	6.6 - 9.6	2.6	1.9
Creatinine	µmol/L	165	138 - 192	143	135
Uric acid	µmol/L		24 - 37	39	44
Calcium	mmol/L	2.45	2.26-2.64	2.48	2.32
Phosphorus	mmol/L	2.00	1.50-2.50	1.55	1.45
Magnesium	mmol/L	0.94	0.81-1.08	0.86	0.67
Total Protein	G/L		72 - 82	71	77
Albumin	G/L		34 - 40	31	30
Alb/Glob ratio		0.92	0.80-1.05	0.78	0.64
Sodium	mmol/L	142	138 - 145	138	142
Potassium	mmol/L	4.1	3.5 - 4.7	4.0	4.0
Chloride	mmol/L	101	98 - 104	91	97
Iron	µmol/L	29	20 - 37	22	20
Iron BC	µmol/L	46	37 - 55	29	24
TIBC	µmol/L	75	57 - 92	51	44
Amylase	U/L	31		69	79

Bovine Hematology (Ranch B)

Test	S.I.Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940315 BT64	# 940316 BT153
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70	6.85	7.17
Hemoglobin	g/L	127	99 - 156	119	132
Hematocrit		0.35	0.27 - 0.44	0.32	0.36
Mean corpuscular volume	fL	45	34 - 56	47	50
Mean corpuscular hemoglobin	pg	16	13 - 19	17	18
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	370	370
Red cell Distribution width	%	23	5.4 - 41	9.0	8.8
Platelets	$\times 10^9/L$	425	189 - 662	205	447
Mean Platelet volume	fL	7.0	5.1 - 8.9	7.6	7.1
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5	9.4	7.8
Neutrophils Rel.		0.21	0.05 - 0.37	0.27	0.17
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59	2.54	1.33
Bands Rel.		0	0	-	0.02
Abs.	$\times 10^9/L$	0	0 - 0.05	-	0.16
Lymphocytes Rel.		0.70	0.48 - 0.93	0.58	0.60
Abs.	$\times 10^9/L$	6.0	2.2 - 11.61	5.45	4.68
Monocytes Rel.		0.04	0 - 0.08	0.03	0.07
Abs.	$\times 10^9/L$	0.30	0 - 1.03	0.28	0.55
Eosinophils Rel.		0.05	0 - 0.14	0.12	0.13
Abs.	$\times 10^9/L$	0.46	0 - 1.77	1.13	1.01
Basophils Rel.		0	0 - 0.01	-	0.01
Abs.	$\times 10^9/L$	0	0 - 0.08	-	0.08
Fibrinogen	g/L			1	1

Bovine Clinical Chemistry (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940317 BT 17	# 940318 BT50 Blue
CPK	U/L	228	55 - 401	237	177
LDH	U/L	1267	939 - 1595	1462	1274
SGOT/AST	U/L	80	62 - 98	95	95
SGPT/ALT	U/L	37	0 - 40	35	22
Alk. Phos.	U/L	149	0 - 312	38	64
Gamma GT	U/L	16	9 - 23	15	16
Total Bilirubin	µmol/L	2	0 - 4	2	1
Glucose	mmol/L	4.8	3.1 - 6.4	3.9	3.7
BUN	mmol/L	8.1	6.6 - 9.6	3.0	1.7
Creatinine	µmol/L	165	138 - 192	135	131
Uric acid	µmol/L		24 - 37	45	56
Calcium	mmol/L	2.45	2.26-2.64	2.41	2.34
Phosphorus	mmol/L	2.00	1.50-2.50	1.30	1.42
Magnesium	mmol/L	0.94	0.81-1.08	0.84	0.78
Total Protein	G/L		72 - 82	74	85
Albumin	G/L		34 - 40	37	30
Alb/Glob ratio		0.92	0.80-1.05	1.00	0.55
Sodium	mmol/L	142	138 - 145	139	138
Potassium	mmol/L	4.1	3.5 - 4.7	4.6	4.1
Chloride	mmol/L	101	98 - 104	96	95
Iron	µmol/L	29	20 - 37	23	20
Iron BC	µmol/L	46	37 - 55	31	26
TIBC	µmol/L	75	57 - 92	54	46
Amylase	U/L	31		76	102

Bovine Hematology (Ranch B)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940317 BT17	# 940318 BT50Blue
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70	6.90	6.59
Hemoglobin	g/L	127	99 - 156	127	120
Hematocrit		0.36	0.27 - 0.44	0.35	0.33
Mean corpuscular volume	fL	45	34 - 56	50	50
Mean corpuscular hemoglobin	pg	16	13 - 19	18	18
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	367	366
Red cell Distribution width	%	23	5.4 - 41	7.9	8.6
Platelets	$\times 10^9/L$	425	189 - 662	273	551
Mean Platelet volume	fL	7.0	5.1 - 8.9	7.7	6.0
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5	8.7	7.4
Neutrophils Rel.		0.21	0.05 - 0.37	0.31	0.22
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59	2.70	1.63
Bands Rel.		0	0	-	-
Abs.	$\times 10^9/L$	0	0 - 0.05	-	-
Lymphocytes Rel.		0.70	0.48 - 0.93	0.48	0.57
Abs.	$\times 10^9/L$	6.0	2.2 - 11.61	4.18	4.22
Monocytes Rel.		0.04	0 - 0.08	0.06	0.04
Abs.	$\times 10^9/L$	0.30	0 - 1.03	0.52	0.30
Eosinophils Rel.		0.05	0 - 0.14	0.14	0.16
Abs.	$\times 10^9/L$	0.46	0 - 1.77	1.22	1.18
Basophils Rel.		0	0 - 0.01	0.01	0.01
Abs.	$\times 10^9/L$	0	0 - 0.08	0.09	0.07
Fibrinogen	g/L			1	2

## Bovine Clinical Chemistry (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940319 Calf 61	# 940320 Calf 15
CPK	U/L	228	55 - 401	299	68
LDH	U/L	1267	939 - 1595	847	625
SGOT/AST	U/L	80	62 - 98	65	38
SGPT/ALT	U/L	37	0 - 40	19	7
Alk. Phos.	U/L	149	0 - 312	187	488
Gamma GT	U/L	16	9 - 23	34	183
Total Bilirubin	µmol/L	2	0 - 4	< 1	18
Glucose	mmol/L	4.8	3.1 - 6.4	5.2	3.8
BUN	mmol/L	8.1	6.6 - 9.6	3.3	3.8
Creatinine	µmol/L	165	138 - 192	93	123
Uric acid	µmol/L		24 - 37	61	72
Calcium	mmol/L	2.45	2.26-2.64	2.44	2.63
Phosphorus	mmol/L	2.00	1.50-2.50	2.73	3.22
Magnesium	mmol/L	0.94	0.81-1.08	0.66	0.69
Total Protein	G/L		72 - 82	64	75
Albumin	G/L		34 - 40	28	23
Alb/Glob ratio		0.92	0.80-1.05	0.78	0.44
Sodium	mmol/L	142	138 - 145	140	139
Potassium	mmol/L	4.1	3.5 - 4.7	6.0	6.1
Chloride	mmol/L	101	98 - 104	99	95
Iron	µmol/L	29	20 - 37	18	6
Iron BC	µmol/L	46	37 - 55	57	72
TIBC	µmol/L	75	57 - 92	75	86
Amylase	U/L	31		72	102
Direct Bilirubin	µmol/L		0 - 1		6

Bovine Hematology (Ranch B)

Test	S.I.Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940319 61a	# 940320 15a
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70	6.00	6.94
Hemoglobin	g/L	127	99 - 156	100	105
Hematocrit		0.36	0.27 - 0.44	0.26	0.28
Mean corpuscular volume	fL	45	34 - 56	43	41
Mean corpuscular hemoglobin	pg	16	13 - 19	17	15
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	387	371
Red cell Distribution width	%	23	5.4 - 41	16.5	12.1
Platelets	$\times 10^9/L$	425	189 - 662	786	800
Mean Platelet volume	fL	7.0	5.1 - 8.9	5.4	5.8
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5	8.5	18.0
Neutrophils Rel.		0.21	0.05 - 0.37	0.36	0.57 <sup>a</sup>
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59	3.06	10.26
Bands Rel.		0	0	0.02	0.11
Abs.	$\times 10^9/L$	0	0 - 0.05	0.17	1.98
Lymphocytes Rel.		0.70	0.48 - 0.93	0.51	0.29
Abs.	$\times 10^9/L$	6.0	2.2 - 11.61	4.34	5.22
Monocytes Rel.		0.04	0 - 0.08	0.11	0.03
Abs.	$\times 10^9/L$	0.30	0 - 1.03	0.94	0.54
Eosinophils Rel.		0.05	0 - 0.14	-	-
Abs.	$\times 10^9/L$	0.46	0 - 1.77	-	-
Basophils Rel.		0	0 - 0.01	-	-
Abs.	$\times 10^9/L$	0	0 - 0.08	-	-
Fibrinogen	g/L			4	4

<sup>a</sup> Toxic vaculation of the neutrophils

Bovine Clinical Chemistry (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940321 Calf 89	# 940322 Calf 89-1
CPK	U/L	228	55 - 401	189	153
LDH	U/L	1267	939 - 1595	786	780
SGOT/AST	U/L	80	62 - 98	51	43
SGPT/ALT	U/L	37	0 - 40	9	7
Alk. Phos.	U/L	149	0 - 312	331	369
Gamma GT	U/L	16	9 - 23	22	26
Total Bilirubin	µmol/L	2	0 - 4	6	4
Glucose	mmol/L	4.8	3.1 - 6.4	5.1	5.5
BUN	mmol/L	8.1	6.6 - 9.6	2.6	2.0
Creatinine	µmol/L	165	138 - 192	111	106
Uric acid	µmol/L		24 - 37	55	38
Calcium	mmol/L	2.45	2.26-2.64	2.83	2.49
Phosphorus	mmol/L	2.00	1.50-2.50	3.21	3.34
Magnesium	mmol/L	0.94	0.81-1.08	0.70	0.77
Total Protein	G/L		72 - 82	59	53
Albumin	G/L		34 - 40	29	29
Alb/Glob ratio		0.92	0.80-1.05	0.97	1.21
Sodium	mmol/L	142	138 - 145	143	138
Potassium	mmol/L	4.1	3.5 - 4.7	6.2	6.7
Chloride	mmol/L	101	98 - 104	101	99
Iron	µmol/L	29	20 - 37	39	35
Iron BC	µmol/L	46	37 - 55	46	49
TIBC	µmol/L	75	57 - 92	85	84
Amylase	U/L	31		64	52

Bovine Hematology (Ranch B)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940321 89a	# 940322 89-1
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70	6.52	7.20
Hemoglobin	g/L	127	99 - 156	100	116
Hematocrit		0.36	0.27 - 0.44	0.27	0.29
Mean corpuscular volume	fL	45	34 - 56	42	41
Mean corpuscular hemoglobin	pg	16	13 - 19	15	16
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	370	395
Red cell Distribution width	%	23	5.4 - 41	12.1	14.8
Platelets	$\times 10^9/L$	425	189 - 662	813	588
Mean Platelet volume	fL	7.0	5.1 - 8.9	5.7	6.3
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5	10.2	18.7
Neutrophils Rel.		0.21	0.05 - 0.37	0.58	0.60
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59	5.92	11.22
Bands Rel.		0	0	0.01	0.01
Abs.	$\times 10^9/L$	0	0 - 0.05	0.10	0.19
Lymphocytes Rel.		0.70	0.48 - 0.93	0.36	0.37
Abs.	$\times 10^9/L$	6.0	2.2 - 11.61	3.67	6.92
Monocytes Rel.		0.04	0 - 0.08	0.04	0.02
Abs.	$\times 10^9/L$	0.30	0 - 1.03	0.41	0.37
Eosinophils Rel.		0.05	0 - 0.14	-	-
Abs.	$\times 10^9/L$	0.46	0 - 1.77	-	-
Basophils Rel.		0	0 - 0.01	0.01	-
Abs.	$\times 10^9/L$	0	0 - 0.08	0.10	-
Fibrinogen	g/L			3	1

Bovine Clinical Chemistry (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940323 Calf 64	# 940324 Calf 153
CPK	U/L	228	55 - 401	141	90
LDH	U/L	1267	939 - 1595	806	878
SGOT/AST	U/L	80	62 - 98	42	61
SGPT/ALT	U/L	37	0 - 40	6	11
Alk. Phos.	U/L	149	0 - 312	165	818
Gamma GT	U/L	16	9 - 23	24	120
Total Bilirubin	µmol/L	2	0 - 4	4	7
Glucose	mmol/L	4.8	3.1 - 6.4	5.8	6.5
BUN	mmol/L	8.1	6.6 - 9.6	4.5	2.8
Creatinine	µmol/L	165	138 - 192	105	107
Uric acid	µmol/L		24 - 37	50	37
Calcium	mmol/L	2.45	2.26-2.64	2.58	2.80
Phosphorus	mmol/L	2.00	1.50-2.50	2.76	3.13
Magnesium	mmol/L	0.94	0.81-1.08	0.69	0.83
Total Protein	G/L		72 - 82	61	53
Albumin	G/L		34 - 40	32	25
Alb/Glob ratio		0.92	0.80-1.05	1.10	0.89
Sodium	mmol/L	142	138 - 145	141	145
Potassium	mmol/L	4.1	3.5 - 4.7	5.8	6.1
Chloride	mmol/L	101	98 - 104	98	100
Iron	µmol/L	29	20 - 37	32	40
Iron BC	µmol/L	46	37 - 55	63	57
TIBC	µmol/L	75	57 - 92	95	97
Amylase	U/L	31		70	105

Bovine Hematology (Ranch B)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940323 64a	# 940324 153a
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70	8.01	7.11
Hemoglobin	g/L	127	99 - 156	123	108
Hematocrit		0.36	0.27 - 0.44	0.33	0.29
Mean corpuscular volume	fL	45	34 - 56	41	40
Mean corpuscular hemoglobin	pg	16	13 - 19	15	15
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	375	379
Red cell Distribution width	%	23	5.4 - 41	12.6	16.9
Platelets	$\times 10^9/L$	425	189 - 662	994	633
Mean Platelet volume	fL	7.0	5.1 - 8.9	5.2	6.3
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5	7.0	11.4
Neutrophils Rel.		0.21	0.05 - 0.37	0.47	0.33
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59	3.29	3.76
Bands Rel.		0	0	0.01	0.01
Abs.	$\times 10^9/L$	0	0 - 0.05	0.07	0.11
Lymphocytes Rel.		0.70	0.48 - 0.93	0.51	0.62
Abs.	$\times 10^9/L$	6.0	2.2 - 11.61	3.57	7.07
Monocytes Rel.		0.04	0 - 0.08	0.01	0.03
Abs.	$\times 10^9/L$	0.30	0 - 1.03	0.07	0.34
Eosinophils Rel.		0.05	0 - 0.14	-	0.01
Abs.	$\times 10^9/L$	0.46	0 - 1.77	-	0.11
Basophils Rel.		0	0 - 0.01	-	-
Abs.	$\times 10^9/L$	0	0 - 0.08	-	-
Fibrinogen	g/L			5	2

Bovine Clinical Chemistry (Ranch B)

Test	S.I. Unit	AEC Normals - Adults		Animal ID	
		Mean	Range	# 940325 Calf 17	# 940326 Calf 50
CPK	U/L	228	55 - 401	167	119
LDH	U/L	1267	939 - 1595	845	648
SGOT/AST	U/L	80	62 - 98	45	42
SGPT/ALT	U/L	37	0 - 40	7	6
Alk. Phos.	U/L	149	0 - 312	712	132
Gamma GT	U/L	16	9 - 23	27	20
Total Bilirubin	µmol/L	2	0 - 4	5	2
Glucose	mmol/L	4.8	3.1 - 6.4	7.5	4.8
BUN	mmol/L	8.1	6.6 - 9.6	3.6	4.9
Creatinine	µmol/L	165	138 - 192	111	88
Uric acid	µmol/L		24 - 37	44	48
Calcium	mmol/L	2.45	2.26-2.64	2.64	2.56
Phosphorus	mmol/L	2.00	1.50-2.50	3.71	2.64
Magnesium	mmol/L	0.94	0.81-1.08	0.79	0.70
Total Protein	G/L		72 - 82	60	57
Albumin	G/L		34 - 40	31	30
Alb/Glob ratio		0.92	0.80-1.05	1.07	1.11
Sodium	mmol/L	142	138 - 145	142	138
Potassium	mmol/L	4.1	3.5 - 4.7	5.3	5.9
Chloride	mmol/L	101	98 - 104	99	98
Iron	µmol/L	29	20 - 37	17	22
Iron BC	µmol/L	46	37 - 55	72	64
TIBC	µmol/L	75	57 - 92	89	86
Amylase	U/L	31		75	71

Bovine Hematology (Ranch B)

Test	S.I. Unit	AEC Normals -Adults		Animal ID	
		Mean	Range	# 940325 17a	# 940326 50a
Red Blood Count	$\times 10^{12}/L$	7.87	6.05 - 9.70	7.11	6.55
Hemoglobin	g/L	127	99 - 156	112	97
Hematocrit		0.36	0.27 - 0.44	0.30	0.27
Mean corpuscular volume	fL	45	34 - 56	42	41
Mean corpuscular hemoglobin	pg	16	13 - 19	16	15
Mean corpuscular hemoglobin conc.	g/L	356	329 - 382	375	363
Red cell Distribution width	%	23	5.4 - 41	13.0	13.6
Platelets	$\times 10^9/L$	425	189 - 662	734	867
Mean Platelet volume	fL	7.0	5.1 - 8.9	5.4	5.3
White Blood Count	$\times 10^9/L$	8.5	4.5 - 12.5	8.7	6.9
Neutrophils Rel.		0.21	0.05 - 0.37	0.37	0.39
Abs.	$\times 10^9/L$	1.76	0.22 - 4.59	3.22	2.69
Bands Rel.		0	0	0.01	0.01
Abs.	$\times 10^9/L$	0	0 - 0.05	0.09	0.07
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Monocytes Rel.		0.04	0 - 0.08	0.02	0.03
Abs.	$\times 10^9/L$	0.30	0 - 1.03	0.17	0.21
Eosinophils Rel.		0.05	0 - 0.14	-	-
Abs.	$\times 10^9/L$	0.46	0 - 1.77	-	-
Basophils Rel.		0	0 - 0.01	0.01	-
Abs.	$\times 10^9/L$	0	0 - 0.08	0.09	-
Fibrinogen	g/L			2	7

**ADMINISTRATIVE SERVICES**  
**WORD DOCUMENT DATA SHEET**

**LONG DOC TITLE:**

**1994 LIVESTOCK FIELD INVESTIGATIONS OF TWO RANCHES ASSOCIATED WITH  
A PIPELINE BREAK**

**RPT**

**M. MOSTROM, C. CAMPBELL, S.L. HERBUT**

**130**

**CUMENT TYPE:**

**AUTHOR:**

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A Abstract

P Acquisition Proposals

B Bibliographies

Budget

Chapter/Book

Client Report

Contract

Centre Report (AEC Green Report)

Form

Journal Report

Labels

Lists

Letter

Miscellaneous

T Minutes of Meetings/Agenda

Manuscript with Tables

Performance Appraisals

Personnel - General

Paper for Proceedings

PML Procedures Manual

POD Position Description

POS Poster Presentations/Sessions

PRG Progress Reports

PRM Program Outline

PRO Proceedings (Entire)

PRP Program/Project Proposals

PST Postscript Files

PTL Protocol

PUD Purchasing Documents

PUR Public Relations Documents

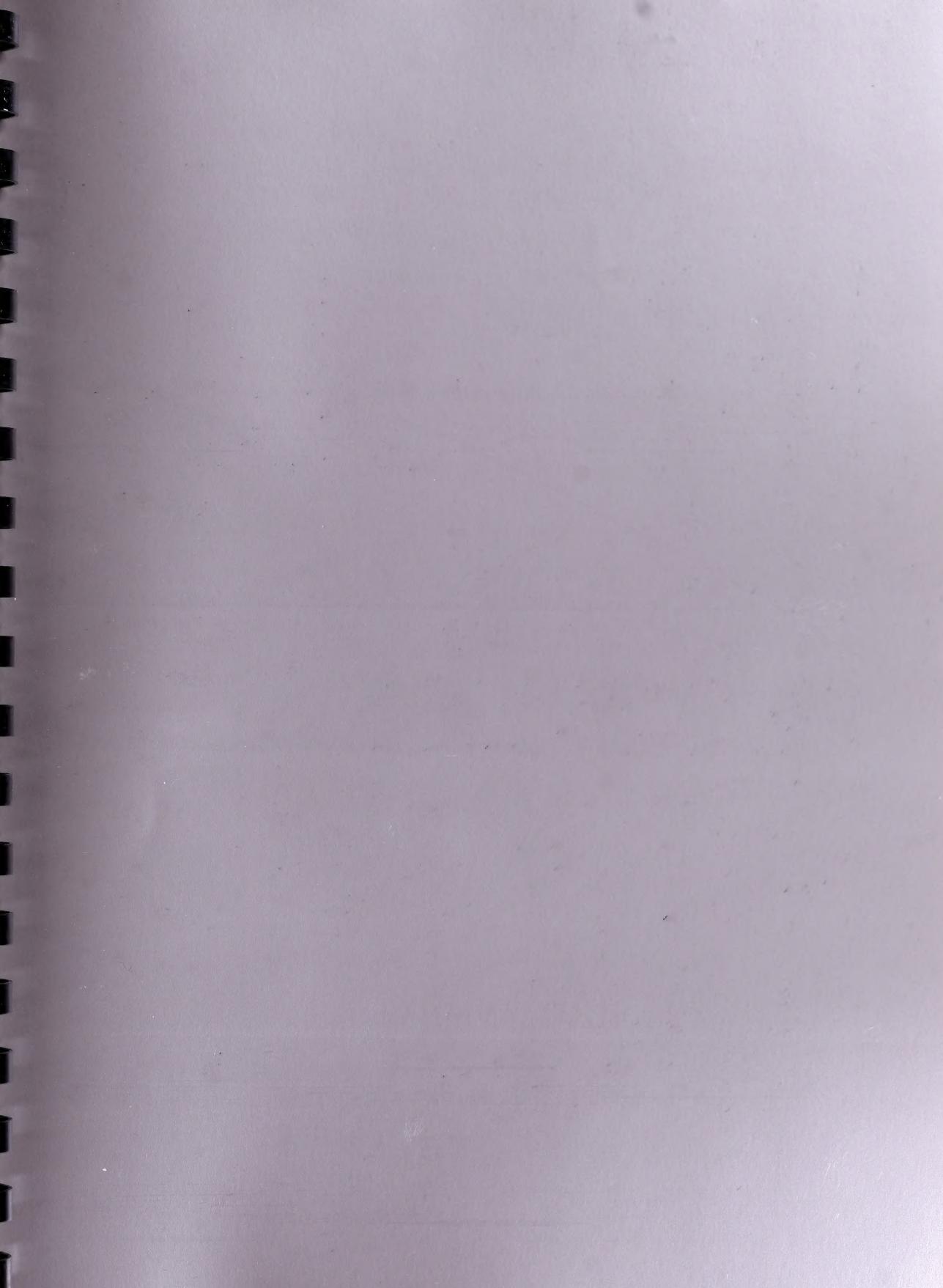
RPT Report (Narrative Text)

SOP Standard Operating Procedures

STC Statistical Tables (Tables & Charts)

TRP Transparencies







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